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MINERAL
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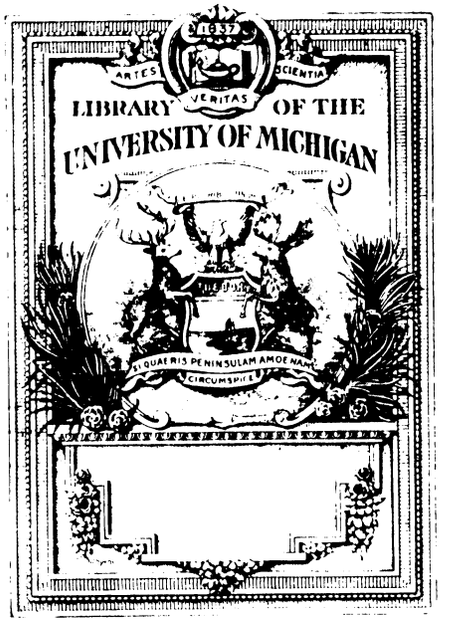

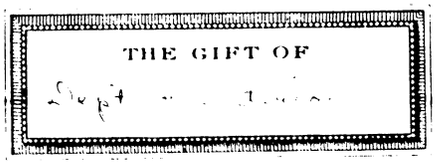

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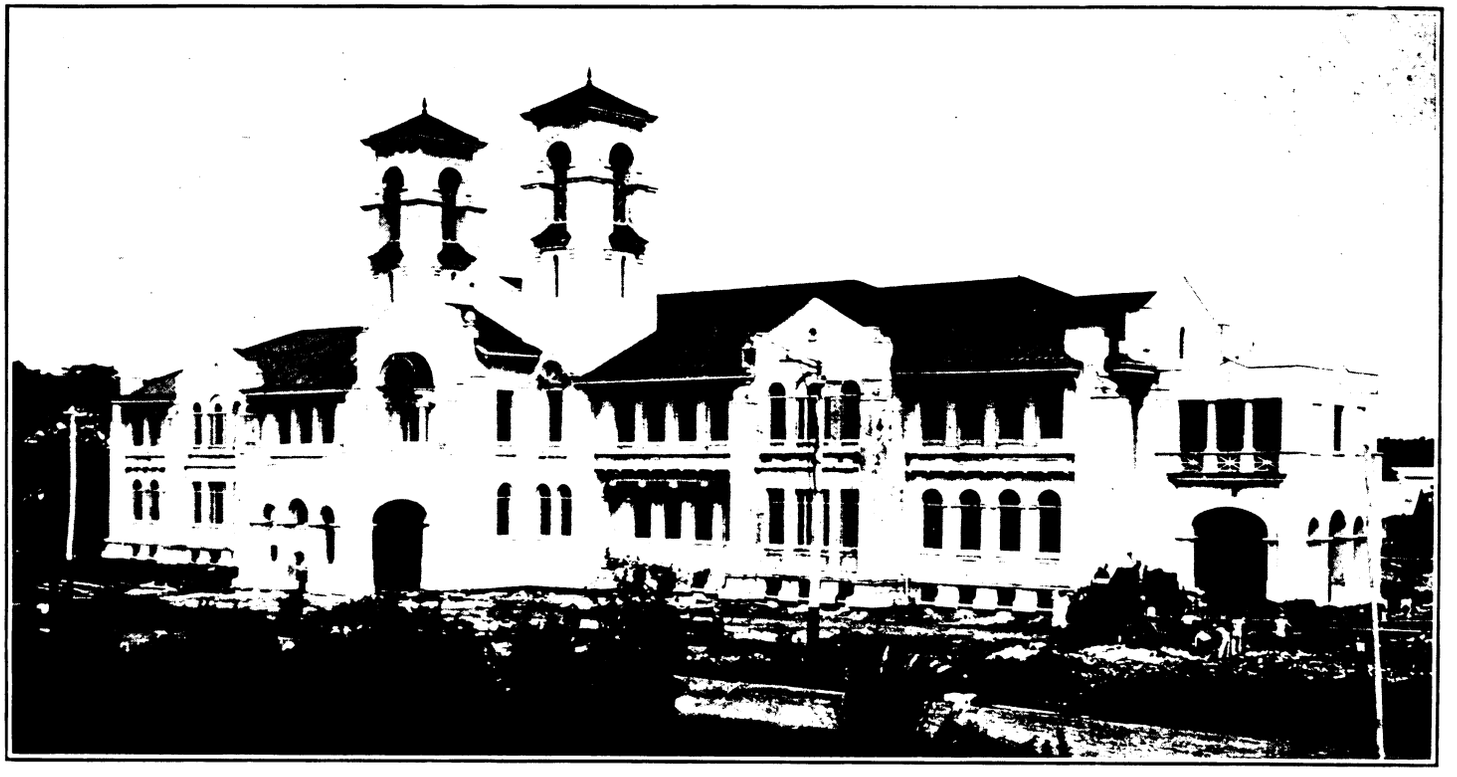

PLATE I. VIEW OF THE LABORATORY OF THE BUREAU OF SCIENCE.

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DEPARTMENT OF THE INTERIOR
THE BUREAU OF SCIENCE
MANILA

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS

WITH A STATEMENT OF THE PRODUCTION OF COMMERCIAL MINERAL PRODUCTS DURING THE YEAR 1907

ISSUED BY

WARREN D. SMITH

CHIEF OF THE DIVISION OF GEOLOGY AND MINES,
BUREAU OF SCIENCE

MANILA
BUREAU OF PRINTING
1908

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THE BUREAU OF SCIENCE.

PAUL C. FREER, DIRECTOR.

THE DIVISION OF MINES

WARREN D. SMITH, *geologist, chief of division.*
MAURICE GOODMAN, *mining engineer.*
HARRY M. ICKIS, *topographer.*
HENRY G. FERGUSON, *assistant geologist.*

The chemical work of the division of mines is done by the chemical division of the Bureau.

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Harry M. Ickis, E. M.

DIVISION OF MINES
BUREAU OF SCIENCE

April the first
1908

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FIELD WORK.

During the year 1907–8 the work and distribution of the division field parties was as follows:

1. Completion of geologic mapping in the Compostela-Danao coal field, Cebu, Messrs. Smith and Goodman.

2. Geologic investigation in the Batanes Islands, Mr. Ferguson.

3. Triangulation in the Aroroy mining district, Masbate, Messrs. Goodman and Ickis.

4. Topographic and geologic mapping of the Aroroy district, begun by Mr. Ferguson, assisted by Mr. R. N. Clark.

5. Underground survey of the old and new Mancayan-Suyoc copper workings, Lepanto-Bontoc, Mr. Goodman.

6. Preliminary investigation of the gold-bearing region of Cagayan de Misamis, Mindanao, Mr. Ickis.

7. Geologic reconnaissance of Mindanao and the Sulu Group, begun by Mr. W. D. Smith, assisted by Messrs. Goodman and Ickis.

8. Investigation of the placer gold fields of Nueva Ecija, Mr. Goodman.

The Mindanao and Masbate work are still in progress.

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THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS.

INTRODUCTION.

The publication of an annual statement in figures of the mineral production in the Philippine Islands is begun with this bulletin. The Bureau has practically adopted the plan so admirably elaborated and so successfully used by the United States Geological Survey in its statistical work. The value of definite and accurate reports can not be too greatly emphasized. The investor needs facts and not mere generalization. Many of our mining men have realized this and have responded generously with what information they could. However, there has been some opposition, but this was to be expected in a new country. There is really no good, sound reason for such an attitude. Publicity will do no harm to the mining interests, but it will be a benefit. The old custom of withholding information from the public is becoming obsolete. We sincerely hope that our efforts in publishing an annual statement of the mineral resources of the Philippine Islands will be appreciated and supported by the mining men of the Philippines.

There are many factors which affect any industry for better or for worse. Some of these we can do very little to change, some obstacles we can partially remove, while others which are devised by man are entirely within our power to modify. Natural features of the country are sometimes insurmountable, the labor question is often a serious one, but when we come to human laws there is no reason why an equitable and proper code could not be devised. A bill is now before the Congress of the United States which will do much to alleviate the present conditions and this Bureau will do all in its power to assist in its passage.

In the interest of the welfare of the mining industry of the Philippines, the mining division wishes to impress upon the minds of the prospectors and mine owners the desirability of conservative advertising. It would be better for a new mining district to wait, however impatiently, until its resources are finally appreciated than to attempt to force matters through statements that, however honestly made, may be misleading or false. No business can be fairer or cleaner than legitimate mining, honestly conducted. Particularly is this true of gold mining where the market of the product remains independent of any possible trust combination or competition. Mining and metallurgy have become far more exact sciences than could ever be claimed for them in the past, and an estimate

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of the true value of a mining property which has been properly opened up and developed may be obtained by a competent mining engineer with a far greater degree of accuracy than the uninitiated may suspect.

A very common cause of failure of a mine is the premature purchase and installation of mining machinery. Not only may the machinery purchased be ill adapted to treat the bulk of the ore to be extracted from the mine in the future, but the mill site chosen before the plans of development are finally decided upon may frequently be so badly located as not to permit of economy in the transportation of the ore between the mine and the mill; worst of all, a more or less complete plant may be installed with no ore to work. In nearly all cases this can be attributed to short-sightedness on the part of the managers and owners who, desirous of making a good showing to facilitate the selling of stock in the mine, have invested their limited capital in machinery rather than in prospecting and development. The result usually is more or less stock sold, a small amount of the ore either on the dump or from near the surface worked out, and then all the machinery stopped. Another failure is then recorded and the brunt of it to a large extent falls upon the other mines and prospects in the district. The chief asset of any mine is the ore reserve.

Mine inspection should be mentioned at this time as a question for future serious consideration. Up to the present there has been no need of this, but the time is almost ripe for some legislation. A reason for delay in putting the measures into immediate execution is that they would involve the taking of the professional men of the division of mines from more urgent work. The subject is mentioned here simply to guide public thought in this direction.

In conclusion it might be stated that the history of the district of Benguet demonstrates that a sure, profitable and steady mining industry can be built up in the Islands.

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(Photo by Ledyard.)

PLATE II. A GOLD MINE AND CYANIDE PLANT IN BENGUET.

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THE NONMETALLIC MINERALS.

By Warren D. Smith.

In many countries, where accurate statistics have been kept, the monetary value of the nonmetallic minerals exceeds that of the metallic products. For the year 1906 the total value of the nonmetallic products in the United States amounted to $1,016,206,700 as against $886,110,856 for the metallic.

FUELS.

Coal.—Coal has been found in nearly every island of this Archipelago; in many places associated with petroleum. The coal is pretty much alike throughout the Philippines, it is sub-bituminous, having the appearance and specific gravity of lignite, but it has the carbon content and streak of a bituminous coal. When mined from beds near the surface and from those which have been little disturbed since their deposition, the coal is apt to be very inferior, having only about 50 per cent of the efficiency of Australian coal, but in regions like the Compostela and Danao fields, or the western end of Batan Island, it is of a decidedly better grade. This superiority is due not so much to compression in folding, or to volcanic heat, as it is to the fracturing of the coal, so that a process of dry distillation takes place and a greater quantity of fixed carbon is segregated. The promising coal fields at the present time are as follows: Cebu, in the region behind the towns of Compostela and Danao; the Island of Polillo, which is on the east coast of Luzon about opposite Manila; the southern portion of the Island of Mindoro in the vicinity of Bulalacao; on a small island just to the south of Bulalacao; Batan Island, about 12 miles northeast of Legaspi, in Albay Province; the northern portion of Dinagat Island, just north of Surigao, Mindanao; and near Escalante in the northeast corner of the Island of Negros.

While these coals have stood some very good tests in stationary and marine engines, still they are far from satisfactory for all requirements, and, following the lead of the United States Geological Survey at St. Louis, Dr. Cox, of the division of chemistry, has experimented with them with the view of establishing the feasibility of utilizing the gases in gas-producer engines. Theoretically, his conclusions appear to be correct, that is, it is feasible to utilize them in this way; but the next

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step is a mechanical one and it is here that the most trouble has been experienced in employing producer coal-gas both in the United States and other countries. However, we feel sure that in time the problem will be solved so that it will be a practicable undertaking. I should state here that Mr. Gilkerson, mechanical engineer at the Bureau of Science, and Dr. Cox are designing and arranging for the erection of apparatus on a large enough scale to make a complete and practical commercial test of this process.

It is not a question with us of the quantity of coal so much as it is one of ability to mine it without a loss. In one sense the geologies of the Philippines and Japan are very similar; that is, in structure both regions are profoundly folded and faulted, which condition of course increases the difficulties of mining. During my last visit in Cebu I traversed one small creek in which I passed in succession across four coal beds—No. 1 was 5 feet thick; No. 2 about 10 feet; No. 3 approximately 13 feet, and No. 4, 2 feet. These beds appeared to be fairly continuous and I may state that a bed of coal 6 feet thick is considered by many engineers as good as one of 40 feet, because it is easier to mine.

Natural gas.—In Rizal Province and on the Island of Marinduque some small amounts of natural gas have been found to issue from the ground, but further than this we have no record of these occurrences and so far as I know they have elicited but scant notice.

Petroleum.—The subject of petroleum I treated more at length in special reports which were published in the Far Eastern Review. Suffice it to say here that petroleum occurs on the east coast of Tayabas Province where prospecting is now going on. On the west coast of the island of Cebu, near Toledo and also near Alegria, petroleum has been found.

One very serious point needs to be considered with great care before any company should venture into the petroleum industry in these Islands, namely, the one involving the structural features of the oil-bearing regions. Are the oil-bearing formations sufficiently extensive and thick, or continuous, to insure a steady and adequate supply so as to warrant any considerable outlay? I am inclined to think that, so far as I know the Cebu field, these conditions are not as favorable as they might be. Without a very considerable oil supply a local company might find serious difficulty in producing any effect on a market already controlled. However, this is a purely business feature which it is not within my province to discuss. I merely make these statements as suggestions.

MATERIALS OF CONSTRUCTION.

Cement.—I am frequently asked if there is any great amount of natural cement rock in these Islands. We have not yet found such materials nor would it make any serious difference if we were not to, for the simple reason that it is possible to take the raw products, limestone

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and clay or shale, and to make a far better product than nature. Sometimes nature succeeds in making a very good cement, but this is only an accident and a very uncommon occurrence. We have in several places all the material for our purpose. We have literally hundreds of square miles of a very excellent limestone, and shale and clay beds are by no means uncommon.

One of the best places for a cement plant would seem to be at Danao, Cebu. Coal, limestone, clay, shale and transportation are all at hand. Good materials and facilities are also available at Cotabato, Moro Province, so that whenever this district shall become thoroughly quieted and more settled with Europeans or Americans, something may be done.

At Binangonan, on Laguna de Bay; near Lucena, Tayabas Province, and on Romblon Island all the ingredients necessary for cement are to be found. One feature most favorable to our cement industry is that the limestones in the Philippines are remarkably low in magnesia, a very objectionable ingredient when present in greater quantity than 2 or 3 per cent. In the United States, where practically all the limestones are rich in magnesia, this is becoming a troublesome feature.

Lime.—The two important sources of the Manila supply of lime are: (*a*) Limestone quarries near Binangonan, and (*b*) oyster and other marine shells near Malabon.

(*a*) The annual output of the Binangonan quarries is about 600 tons, nearly all of which is shipped to Manila in a water-slaked condition and is used mostly for making mortar. As a rule but a small supply of burnt lime is kept on hand, the lime being burnt when ordered, then slaked and shipped to Manila either in sacks or barrels. Very little is shipped to Manila unslaked.

The product of the Binangonan kilns is a very fat lime, which swells to about three times its original volume in slaking. In this condition it sells at Binangonan for ₱0.45 per cavan [1] (about 80 pounds) and costs to transport to Manila an additional ₱0.15, making the total cost at Manila about ₱0.60 per cavan. Freshly burnt quicklime can be obtained at Binangonan for about ₱1.35 per cavan, or three times the cost of the slaked lime, and in Manila for about ₱1.50 per cavan.

The total cost of manufacturing the slaked lime at the kiln is about ₱0.22 per cavan. Transportation to Binangonan per carabao costs an additional ₱0.06, making the total cost of production at Binangonan about ₱0.28 per cavan. Assuming the quicklime to triple in volume in slaking, and the cost of transportation to remain the same per volume for quick as for slaked lime, the cost of producing a cavan of quicklime in Manila would be about ₱0.87 per cavan or about ₱2.50 per barrel of 230 pounds. This gives a profit of about ₱0.60 per cavan of quicklime at the present market rate. Padre Reyes finds no difficulty in obtaining

[1] 0.075 cubic meters or 2.65 cubic feet.

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as many laborers as he requires, nor contemplates any difficulty in this respect even though the demand should be largely increased.

(*b*) About 600 tons of slaked lime are annually burnt at Malabon. This lime is poorer in quality and brings a lower price in Manila than the Binangonan lime. It is made of marine shells gathered in the neighborhood of Malabon. The estimated cost of production of the slaked lime is about ₱0.25 per cavan and the cost of transportation to Manila is ₱0.05, making the total cost at Manila about ₱0.30 per cavan. Its selling price here is about ₱0.38 per cavan.

Like the Binangonan lime the major portion of the product is used in making mortar. However, part of it is also employed for whitewashing, and a small amount, especially prepared for the purpose, is used in making the lime paste which is chewed with the betel nut.

Lime is burned at Malolos in Bulacan Province and sells there at ₱0.50 to ₱0.55 per cavan, and farther north, at Guagua and at Sexmoan in the Province of Pampanga, practically the same quality of lime is manufactured, but it brings there ₱0.80 per cavan.

I see no reason why much more lime than is now produced could not be made in Cebu and the other Visayas. Certainly it should not be necessary to import this material, as is now the case.

BUILDING AND MONUMENTAL STONE.

The stone used in Manila may be roughly divided into two classes: (*a*) Marble and small quantities of other stone used for monuments and inside decorations, and (*b*) building stone.

(*a*) There are several firms in Manila using marble for tombstones, memorial tablets, etc. Nearly all of this stone comes from Belgium and Italy; the dark colored and dense black varieties coming from Belgium, and the soft white varieties from Italy. The marble is usually shipped in thin slabs, from ¾ to 4 inches in thickness, but some of it comes in large blocks. The thin slabs vary in size from 3 feet square to 4 by 8 feet, and are often broken or cracked in transmission so as to be almost worthless by the time they arrive in Manila. On the other hand, it is a costly and tedious undertaking to saw thin slabs from massive blocks because of the unsatisfactory labor for the work and the crude methods for sawing in vogue here. Some marble has been brought from the eastern part of the United States, coming by way of San Francisco and the Pacific. The freight by this route is very high, and as the varieties imported were mostly hard Tennessee marbles, the dealers have not taken kindly to the American article. Soft varieties of stone which can be easily worked are preferred. If hard marble is used it should be very tough and difficult to break. If samples of marbles from the United States could be accessible to the merchants of Manila, they could order soft varieties. Better freight rates might be obtained by way of the Suez Canal.

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Practically the only marble of home production comes from the Island of Romblon and it is not well adapted for the finer grades of work.

A considerable quantity of very white crystalline marble has been found in northern Mindoro, but because of the difficulty of transportation and the high cost of the latter no steps have been taken to quarry it.

Dealers are rather reticent concerning the cost of marble in Manila. It varies greatly with the quality of stone, the soft white varieties being the cheapest, and the dense black ones the most expensive. In slabs from ¾ to 1 inch thick it costs, as stated by the dealers, from ₱3 to as high as ₱20 per square meter. The ordinary grayish white variety is bought by the small dealers from the importers at from ₱8 to ₱10 per square meter.

The value of the marble in the finished state depends entirely upon the amount of labor expended upon it. The cost of labor will be found in another place, and the value of a given piece of finished marble may be approximated, but it is not possible to give general figures.

The quality of Belgian and Italian marble is well known and nothing further need be said of marble from the United States. The quality of marble from Romblon leaves much to be desired. Its composition is not uniform, it breaks easily, and is too hard to suit most of the workmen. Its gray color is not attractive, and the dealers say it costs more than the imported stone. While not adapted for fine work it might prove valuable for building stone if it could be quarried, brought to Manila and sold at a reasonable price. I should strongly recommend further investigation of the Romblon stone.

Granites, syenites and like stones are out of favor because of their hardness, and so far as I can learn are not being used for monuments, tombstone, or like purposes. Some of the igneous rocks of these Islands are undoubtedly better than marble for outside work, as marble disintegrates more rapidly when exposed to the weather.

(*b*) At present there is not a good quality of building stone on the market in Manila. In former years considerable quantities of Hongkong granite, a very fine stone, were employed in Manila, but its use in recent years seems to have fallen off.

Volcanic tuff, which is found at the surface of the ground around Manila, is for sale in blocks 7 to 8 inches square, and about 20 inches long, but it is hardly deserving the name of stone. It is very soft, has small crushing strength, rapidly goes to pieces when exposed to the weather, and it is rather unsightly. Its only good qualities are cheapness and the ease with which it can be obtained.

Workmen go to where the tuff is exposed, chop out blocks with bolos or picks, load them on a banca and bring them into Manila. Dealers sell the blocks for ₱9 to ₱12 per hundred.

The Atlantic, Gulf and Pacific Company has blasted out great quantities of rough rock at Mariveles for use about the harbor works in Manila

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Bay, principally in the breakwater. The rock is an acid eruptive, hornblende andesite.

I believe there are no other private stone quarries near Manila producing stone at the present time. There certainly are none of importance. I have been informed that there is a good building stone not far from Manila. It is owned by private individuals, and no development work is being done. The Romblon quarries might prove, on further work, to be a very valuable property for some company.

Transportation is practically all by water. The soft stone blocks from the vicinity of Manila are brought to the city in bancas, although it is done in such an irregular way that actual cost of transportation is not available. The cost of transportation of marble from Italy and Belgium was not to be obtained from dealers, but it was stated to be much less than the freight rates from the United States by the Pacific route.

Filipino labor is used exclusively. For the rough work it does very well, but when great skill is required it is not satisfactory. Proprietors of etsablishments say that the native workmen are very easily offended and resent attempts to teach them. They do not seem anxious to learn. On the other hand for such work as was required at Mariveles the Filipino workmen were very satisfactory and were used to the exclusion of all other people.

In the marble works the men are paid ₱0.50 to ₱2.50 per day, with ₱1.50 as an average. At Mariveles they receive about ₱1.50 per day.

ABRASIVES.

In the southern islands there is a considerable development of sandstone which would work up well into grindstones. On the Muao River, Cebu, I recently found a deposit which appears to be very similar to the novaculite of Arkansas in the United States, the material from which our finest whetstones are made.

CHEMICAL MATERIALS.

Gypsum.—Gypsum has been reported from several localities, but as yet we have no figures as to the extent of the deposits. One locality in the Loboo Mountains, east of the town of Batangas, appears to be quite promising. Gypsum would be used not only in cement manufacture, but also in the making of plaster of Paris. I should say, however, that the purest Rhine cements do not use gypsum and it is to be regarded as an adulterant.

Phosphate.—Phosphate occurs in several different forms, in the mineral apatite as phosphorite or rock phosphate, land pebbles, and in

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guano, which is formed from the excreta of sea birds and bats. In nearly every extensive cave in the Philippines a dirty, coarse, granular soil is encountered on the floor, varying from a few inches to several feet in depth; this is usually a bat guano, the total quantity in each instance varying from several hundred to a thousand tons. It could be mined with profit. The Island of Marinduque is said to have many caves containing this deposit, which in one place is estimated to be as much as 500 tons. I believe the only people in the east who handle this material are the Japanese.

Pyrite.—The chief use for pyrite is in the manufacture of sulphuric acid. As yet I have neither seen nor heard of any extensive deposits of this iron compound, although it is probably the most widely disseminated of all the metallic minerals. I do not believe a plant erected for the purpose of making sulphuric acid alone would pay in the Islands, but as a by-product incident upon the treatment of pyritiferous ores it might find a ready market.

Sulphur.—Sulphur in small quantities has been found in Leyte, in Mindanao, in Luzon, practically everywhere where there has been any recent vulcanism. Mr. Goodman, of this Bureau, on a recent trip through Leyte made a very diligent search for sulphur, visiting some of the locally well-known solfataras, but he did not find any commercially valuable deposits. It would be a distinct advantage if we were to find any considerable quantity of sulphur, as this element is needed in the making of certain kinds of paper. Very good paper has been prepared by Mr. Richmond, of this Bureau, from abacá and cogon waste, but sulphur is needed in the process. I have no doubt in my own mind that there are considerable buried deposits of sulphur intercalated in the general lava flows which will be uncovered at a later time.

Salt.—The occurrence of springs flowing hot saline solutions, either quited saturated or nearly so, appears to indicate the existence of natural salt deposits in the Philippines, although none have been actually encountered. Such springs are known to exist at Mainit near the town of Bontoc, at Asin near the boundary line between Lepanto and Nueva Vizcaya, and near the town of Bambang in Nueva Vizcaya. All of these occurrences are in the interior of northern Luzon and at least 35 miles from the coast.

Mineral paints.—In Ilocos Norte, as well as in many places throughout the Islands, there are considerable accumulations of yellow and red ocher which should make a very fair article. A good quantity of the ground mica and actinolite, greenish in color, also occurs; this might also be worked up into a fair grade of paint.

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MISCELLANEOUS.

As I treated the topic of asbestos more at length in another report I shall briefly pass it over, making the statement here that small amounts of asbestos have been found in Ilocos Norte but that no first grade variety has as yet been located. The quantity so far in sight is limited. Some of the asbestos is fibrous serpentine, but most of it is an amphibole more closely designated as anthophyllite. However, within the last few days very promising specimens of chrysotile have been received from Ilocos Norte. Prospecting is still in progress.

Brick and tile.—Red brick and tile are made near Guadalupe, Rizal Province, from a transported clay of a fair grade. The principal kiln is situated on the banks of the Pasig River. The methods are rather crude. The finished product is brought down the river in bancas and sold in Manila.

Prices of brick and tile.

Article.	Dimension in inches.	Price per 1,000.
Tile	10½ × 10½ × 1	₱80 to ₱100
Brick:		
No. 3	4½ × 8½ × 2	22 to 25
Cornice	3½ × 10½ × 2	22 to 25
Half brick	4½ × 9½ × 1	16

Feldspar.—Feldspar is valuable for glazing purposes in the manufacture of porcelain. In Ilocos Norte, near the Caraon River, there is a considerable deposit of disintegrated quartz and feldspar which could be used in the porcelain industry and in the manufacture of glass. This would not make the best quartz for glass manufacture, as is the case with that derived from a pure sand or a crushed quartzite, but still I think it would do very well.

Fuller's earth.—This material occurs on the township site of Baguio, Benguet.

Magnesite.—Magnesite, or magnesium carbonate, is usually found along rifts in serpentines and pyroxenites. I have seen some patches of it on Batan Island off the Albay coast and in Ilocos Norte, but none in commercially valuable quantities.

Manganese ore.—Manganese ores in the form of pyrolusite, psilomelane and wad have been found in several parts of the Islands; in Masbate, in the Aroroy district, there is so much of it that it is mixed through the vein matter and causes a great deal of trouble on the mill plates. In Zambales Province, on the road from Capas to Iba, a deposit of manganese ore has been penetrated by the road, but we have no figures as to the quantity. In Ilocos Norte there is a very peculiar occurrence of manganese ore, for it is found in this province as nodules, varying from half

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PLATE III. HOT SPRINGS AT TIUI, ALBAY PROVINCE.

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an inch to 2 and 3 inches along their longest diameters, usually somewhat flattened rather than round. These nodules are found scattered all over the surface over acres of ground and in some places, in natural troughs between hills, they are concentrated to the thickness of a foot or more. The deposit is essentially a blanket of natural concentrates. As yet no deposits of sufficient extent and depth to be of certain commercial value have been found, and not enough development has been done to make a fair estimate possible.

Mica.—No sheet mica has been encountered in the Philippines up to the present time, but in Ilocos Norte considerable pockets of a very triturated mica occur. This material could be used for lubricants, "frosting" for Christmas effects, etc., and were some small leaves of mica to be found they could be united into larger sheets of so called "micanite" and used for insulating certain parts of electrical apparatus.

Mineral waters.—Since the year 1893, the date of the publication of the work entitled "Estudio Descriptivo de Algunos Manantiales Minerales de las Filipinas," by Abella and Casarriego, Vera and Gomez and Rosario and Sales, considerable work has been done on spring and mineral waters in the chemical division, Bureau of Science, but the results have not yet been collected and tabulated. Some of the well-known springs recorded in the Spanish work are—

1. The spring of Lanot, near the town of Daet, in the Province of Ambos Camarines. This water contains iron and carbonic acid. Temperature, 26° C.

2. The spring of Pansol, near Calamba, Province of Laguna. This contains the bicarbonates of sodium and potassium. Temperature, 32° to 43° C.

3. The spring of San Mariano de Nagtanglang, town of Pozorrubio, Province of Pangasinan. Temperature, 29° C.

4. The spring of Mainit de Bosoboso, Bosoboso, Province of Rizal. This contains sulphur, besides nitrogenous matter. Temperature, 48° C.

5. The spring of Mulag, pueblo de Carcar, Carcar, Province of Cebu, the water of which is much the same as that from Bosoboso. Temperature, 33° to 34° C.

6. The spring of Tagbag or Bolocboloc, pueblo de Barili, Province of Cebu. This contains a mixture of bicarbonates. Temperature, 31°.5 C.

7. The spring of Meabe, Rancheria, Itogon, in the Province of Benguet. Temperature, 86° C.

8. The spring of Cotabato, pueblo of Cotabato, Mindanao, and several others. Temperature, 38° C.

The two most important waters to-day and which are not mentioned in this report but in an earlier one (1890)[1] are from Sibul Springs, near

[1] Memoria Descriptiva de los Manantiales Minero-Medicinales de la Isla de Luzon, Madrid (1890).

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the pueblo of San Miguel de Mayumo, in Bulacan Province, and the Los Baños water, better known as "Isuan." Both of these have a reputation for beneficial medicinal qualities. The Sibul Spring water has a temperature of only about 27° C. or that of the air, and it emits an appreciable odor of hydrogen sulphide. However, this quickly disappears as no trace of it was found when the water was examined in Manila. The report of the chemist, V. Q. Gana, of this Bureau, classes it as nonthermal, calcic, alkaline, saline.

"Isuan" is classed by V. Q. Gana as a thermal, sodic and calcic, alkaline saline siliceous bicarbonated water. The good qualities of this water have been added to by artificial charging with gas. At the spring it has a temperature of 91° C.

MISCELLANEOUS.

Precious stones.—No stones of gem quality have been reported; however, in Ilocos Norte I have seen some poor specimens of opal which showed a little fire. Diligent search in this region might bring some very fair specimens to light. Some small topazes have been found in streams in Ambos Camarines.

Pumice stone.—In a region of such great vulcanism as ours we should find quantities of pumice; in fact, we do encounter a great amount of pumice fragments scattered throughout the tuff deposits around Manila, but so far I have seen no large pieces of it.

The pearl-shell industry.—There is at the present time only one factory in the Philippines turning out pearl buttons and other small shell articles. This is located in Pandacan on the south bank of the Pasig River. It has been in operation three years and a half.

The shells from which the buttons are manufactured come from Jolo, Mindanao, Cebu, and other southern islands in the Archipelago. They are bought in the open market, chiefly from Chinese, but some are obtained from Filipinos.

The best quality of buttons is made from a flat, nearly circular shell 8 or 9 inches in diameter and one-half to three-quarters inch thick (*Meleagrina* (*Avicula*) *margaritifera*). Another shell from which most of the cheaper grade of buttons are manufactured is a curved shell wound in the form of a spiral and about 6 inches in diameter (local name "carabaos").

The capacity of the plant when all of the machines are running is about 200 gross per day of buttons of many different shapes and sizes. This output requires about 25 tons of rough shells per month. It is believed that this output will be ample to supply the demand for these Islands.

The exact amount of importation at present I have not been able to ascertain but it is estimated that the imports are from 3,000 to 5,000 gross per month.

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There is an almost unlimited market in the East for pearl buttons which are nearly all imported from Europe at the present time. It is expected, however, that the Philippines will consume all of the product of the present plant.

The machinery is all new and apparently of the most improved design. The following is a list of the different machines:

1. One circular saw to divide the curved shells into convenient sizes.
2. Twelve tubular saws for sawing out different sizes of disks from the rough shell.
3. One emery grinder fed by belt which grinds off most of the waste material from the disks.
4. One sorter which separates the disks according to thickness. It consists of two inclined cylinders about 4 feet long close together at the upper end and about one-fourth inch apart at the lower end.
5. Seven grinding machines where all of the waste material is ground off the crude buttons.
6. Twelve machines for making holes in the center of the button to receive a metal disk and eye.
7. Six lathes for making different designs on the face of the button.
8. Four machines for making holes through buttons which are to be fastened with thread.
9. Four revolving polishing barrels into which the completed buttons are charged, together with pumice stone. These barrels are about 20 inches long and 12 inches in diameter.

Nearly all of these machines are simple in construction and easy to operate.

Sand; molding, building, etc., and gravel.—We have no statistics at hand in regard to molding and building sand and gravel. We have an abundant supply of building sand on our beaches; and in the beds of our many rivers we have an unlimited amount of gravel, great quantities of which are being used every year on roads and in concrete work. The only sand that we have found at all approaching a molding sand, which of course must have certain properties, is that occuring as intercalated beds in the tuff deposits near the city of Batangas. This sand is very fine grained, free from pebbles, and can be molded into any shape desired; I think the supply is unlimited.

Talc and soapstone.—The only talc that I have so far seen in the Philippines comes from Ilocos Norte, near the pueblo of Pasuquin. It occurs in irregular pockets with micas and the schist area bordering the serpentine mass. This talc would doubtless find ready application as a loading material for paper.

I have not seen any soapstone nor have I any reports of its occurrence.

Tripoli has been found on the naval reservation at Olongapo.

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METALLIC MINERAL RESOURCES.

By Maurice Goodman.

Gold.—Gold is easily the first in importance of the metallic mineral resources of the Philippines. It has been sought for and found in most of the provinces of the Archipelago, but of them all the Provinces of Benguet, Masbate, and Ambos Camarines are rivals for first place in the metal output and in general mining activity. Numerous claims have been located in these provinces and several corporations have lately been organized to develop and operate a number of the most important groups. The success of some of the companies which have entered the field is yet in doubt, while that of others, to judge from their continuous operation and constant output, might naturally be considered assured. There are other corporations which have not yet attempted to break into the producer class, but have exerted their energies toward developing their properties and in blocking out ore. From the latter class good reports are anticipated in the near future. As the mineral resources of the Philippines have been discussed at length in the past annual reports of the Chief of the Mining Bureau, copies of which may be obtained upon application, it will be necessary here to make mention of the later discoveries and developments only.

Two new stamp mills have recently been imported into the Islands. One, a Hendy quadruple-discharge six-stamp mill, will be erected in Benguet, and the other, a ten-stamp mill of the Risdon type, has been set up in Masbate. On the other hand, a ten and a five stamp mill have been shut down in Masbate, so that the prospects for an increased output this year seem doubtful. However, new discoveries have been made which promise well for the future. At Binanlonan, in the northern part of Pangasinan, some rich but narrow veins of free-milling ore have been discovered and at least two companies are engaged in active exploration work in that field. Unfortunately, internal dissensions have been interfering with rapid progress in this district, but with the settlement of disputes the outlook for the new mining camp seems favorable.

The Island of Marinduque also offers a new, but small field for the prospector. Recent discoveries conclusively prove the presence of gold-bearing veins, and while no bonanzas have been encountered the company most active in prospecting the district declares itself well satisfied with

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the showing thus far made and is prepared, should the prospects continue favorable, to open up and develop its properties on a larger scale.

The gold mining industry in the northern Camarines has been showing signs of awakened interest. While this is more true of placer than of quartz properties, the latter too have recently been the subject of negotiations which have been successfully concluded, and mining operations here have been resumed. These properties are reported to have yielded much rich ore in the past and were the only mines operated with an approach to modern methods during the Spanish régime. For various reasons these mines were abandoned and are to-day in such a condition that it will require a considerable expenditure of money to put them in working shape.

The most recent information received is that the dredge erected about May 1 of last year is yielding returns, and several quartz prospects are being opened up.

The most interesting and probably most important of the recent discoveries of gold, was made in the Suyoc region of southern Lepanto, where the Igorots have been working and washing gold ore by the most primitive methods for a hundred years or more. Many years ago they were driven out of their richest diggings by water, as, because of the topography of the country, they could not work these places by their usual booming method. An American prospector by means of a drainage tunnel has recently removed the water from one of these flooded workings and found the rich ore which tradition reported to be present. A silvery, white mineral since identified as calaverite was observed in association with the free gold, this being the first authentic report of the occurrence of telluride of gold in the Philippines. No report as to the extent of the deposit or the average assay value of the ore has yet been made.

No great amount of bullion was produced during the past year from the placer deposits of the Philippines. One dredge has but recently arrived at its real working field, having been engaged heretofore in laboriously making its way through comparatively poor and more or less barren ground. A New Zealand syndicate imported a gold dredge last year which has since been put together and floated in the Paracale River. Another dredge, which is now lying idle in Masbate, may be transferred to the Camarines in the near future to assist in the exploitation of this rich field.

In Nueva Ecija, ditches and flumes have been constructed and everything is prepared for a profitable sluicing campaign during the coming rainy season. Considerable prospecting has been done during the past year in the placer field of northern Surigao, but no extensive mining operations have yet been undertaken.

Copper.—Scarcely á dollar's worth of copper has been produced in these Islands since American occupation. Nevertheless, this metal is

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readily conceded to rank next to gold in importance as a natural asset of the Philippines. It holds this position both because of its past record, and of its widespread occurrence throughout the Islands, being a frequent associate of gold in the ores. The nonproduction of copper of late years must necessarily be attributed to the absence of smelters in the Islands and to the difficulties of transportation from the mountain regions where the ore has been found, to the nearest port from which the product could be shipped to foreign smelters. With the investment of a moderate amount of capital these difficulties could be overcome, either by the erection of a furnace near the mines or the improvements of transportation facilities. The Mancayan copper mines, which are the most important and best known copper deposits in the Philippines, have lately come under the control of a local syndicate composed of American and English capitalists. This company has applied for and obtained a franchise to build a railroad from Mancayan to Bangar, a town on the western coast of Luzon. If this road is built, a most important step toward the upbuilding of the mineral industry of the Philippines will have been taken, for not only is such a road of prime importance to the interests of the copper company, but all of the gold mines of Suyoc and northern Benguet will be benefited by it. The Mancayan property is now being thoroughly examined by a mining engineer from the United States.

Very promising specimens of the carbonate ores from eastern Pangasinan have recently come to the Bureau, but no authentic reports have yet been received concerning the extent of the deposits. Similar specimens, but no more data, have been recorded from Cagayan de Misamis. Large bowlders of chalcocite float carrying very appreciable quantities of gold and silver have been encountered in Marinduque, but up to the present time the mother lode has not been discovered. Native copper occurring as a very thin stringer in igneous rock has been discovered in Masbate, and rich carbonate ores carrying gold and silver have been found in the same region.

Silver.—Native silver has been obtained only from one of the Suyoc mines, a short distance from where the telluride of gold was discovered. Some rich assays of this ore have been made. As an associate of gold it is encountered in many ores, but in most of them it occurs only in inappreciable quantities. It has been found with lead in the argentiferous galena of Marinduque and Cebu, running over 11 ounces per ton in the former, while in the latter the proportion is unknown, although it is reported to be high.

Lead.—No development work was performed on any of the lead deposits of the Philippines during the last year. The outcrops in Marinduque and Cebu were visited by representatives of the mining division of this Bureau, but the lack of development work made it impossible to formulate a conclusive report upon the probable importance of these

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deposits. A few of the gold ores of the Islands contain a sufficiently high percentage of galena to make it a factor in the estimation of the smelting cost. Large specimens of galena float were found in conjunction with those of chalcocite mentioned above, but as already stated, the parent lode of these bowlders has not yet been discovered. In Cebu the galena occurs as a "stockwork," in or closely associated with an andesite flow.

Iron.—No new developments have taken place in the iron industry of the Philippines during the past year. In the Angat region an improvement in the conditions was caused by the termination of the legal disputes which had been causing more or less molestation to the operators for the last four or five years. An increased economy and possible output may follow as a result of this settlement, but no new discoveries or modifications of the methods employed are reported. The new wagon road being built between San Miguel de Mayumo and Sibul may prove an impetus to the iron smelters of that district, as it will permit of greater economy in the cost of transportation of the product from the mines to the railroad. This has always been one of the largest expenses in this region. Iron ore has been discovered in Marinduque, but under conditions which render an iron industry unlikely in that island within the near future. Iron ore carrying manganese has been reported from near Panopoy, Cebu.

Tellurium.—Tellurium in the form of calaverite and sylvanite has been found occurring in fine streaks in Benguet and Lepanto ore.

Tin.—Considerable stir was caused some months ago by the reported discovery of tin ore in Mindanao. As such a discovery had long been hoped for, the statement at first gained considerable credence. A brief investigation, however, proved the news to be false. No authenticated discovery of tin has been made in the Philippine Islands.

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STATISTICS.

Compiled by W. D. SMITH.

TABLE I.—*Production of metallic and nonmetallic minerals, by provinces, in 1907.*

Province.	Gold.	Silver.	Copper.	Iron.	Coal.	Clay.	Guano.[a]	Miscellaneous.
	Ounces.	*Ounces.*		*Short tons.*	*Short tons.*			
Albay					4,545			
Ambos Camarines	100	7						
Benguet	[b]3,888							
Bulacan				436				
Cebu					[c]			
Ilocos Norte								[d]
La Laguna						[e]		
Lepanto-Bontoc		[f]	[g]					
Sorsogon (Masbate)	552	76						
Total	[h]4,540	83		436	4,545			

[a] A few hundred tons all told have been taken from various caves in Rizal and Batangas Provinces.
[b] About 200 ounces per month are brought in by the Igorots and sold in Baguio. The output of the American mines was given in dollars from which the number of ounces was calculated.
[c] Worked in Spanish times. No production but vigorous development.
[d] Small amounts of manganese and crude asbestos.
[e] The natives and Chinese use a considerable quantity of kaolin for whitewashing.
[f] Some silver ore has been found but has not yet been developed.
[g] Worked in Spanish times, now by Igorots. Development by Americans begun.
[h] I have estimated the total Igorot production to be 2,000 ounces. It is impossible at present to obtain more exact figures.

Although the total production of metallic and nonmetallic minerals is not large, a really insignificant quantity when we consider what the country could and should produce, it is well to include the record given in Table I as the beginning of the future annual tables of production. For the first year this is as accurate a statement as can be made. We hope to include figures next year regarding a number of products such as guano, brick and tile, lime, etc. The scattered condition of these industries, largely native, makes it difficult to secure the information with any accuracy.

Of the 4,540 ounces of gold which from actual figures and estimates make up the total, 2,540 represent the amount taken out by Americans and New Zealanders; the remainder represents the quantity mined by hundreds of Igorots and sold in Baguio. The average fineness of the gold taken out by the American and New Zealand operators was 0.850.

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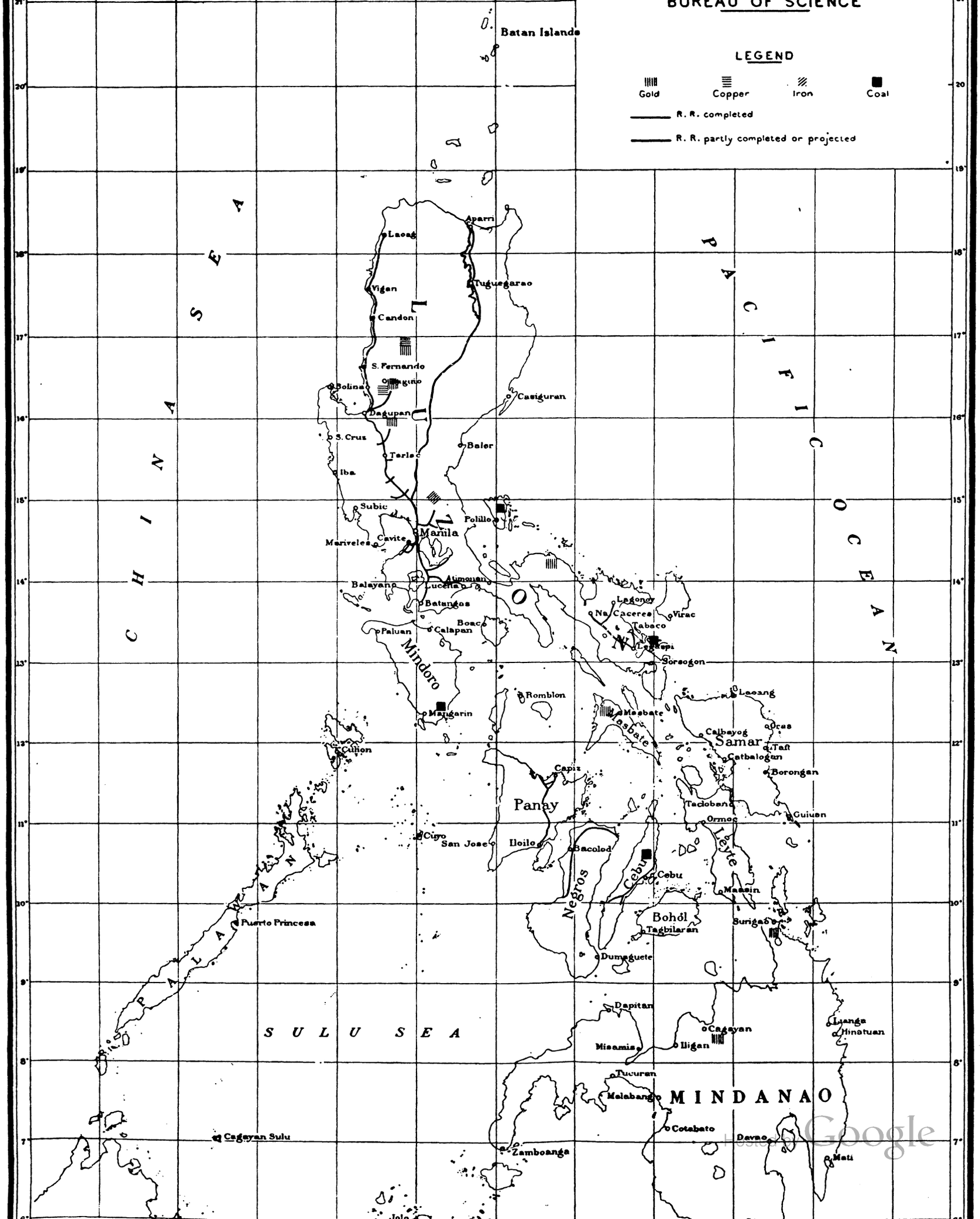
BUREAU OF SCIENCE
LEGEND
Gold
Copper
Iron
Coal
R. R. completed
R. R. partly completed or projected
Batan Islands
Aparri
Laoag
Tuguegarao
Vigan
Candon
S. Fernando
Bolinao
Dagupan
Casiguran
S. Cruz
Tarlac
Baler
Iba
Subic
Manila
Polillo
Mariveles
Cavite
Balayan
Lucena
Batangas
Boac
Paluan
Calapan
Mindoro
Romblon
Mangarin
Legaspi
Sorsogon
Masbate
Leyte
Samar
Calbayog
Catbalogan
Borongan
Tacloban
Ormoc
Guiuan
Capiz
Panay
Culion
Cuyo
San Jose
Iloilo
Bacolod
Negros
Cebu
Bohol
Tagbilaran
Dumaguete
Puerto Princesa
Dapitan
Cagayan
Misamis
Iligan
Surigao
Hinatuan
Tucuran
Malabang
MINDANAO
Cotabato
Davao
Mati
Cagayan Sulu
Zamboanga
Jolo
CHINA SEA
PACIFIC OCEAN
SULU SEA
PALAWAN

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(Courtesy of Far Eastern Review.)

PLATE IV. IGOROT MINES IN BENGUET.

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Some of the Igorot gold recovered as nuggets and stringers would doubtless be finer, but a certain proportion of their gold has been found to be alloyed with copper to such an extent that an ounce would not be worth over $10. It is to be regretted that our figures can not be more definite, but this is our first attempt at compiling statistics in the Philippines.

When it is remembered that the Igorots use no machinery and all the other gold excepting that which came from one dredge set up last May has come from two stamp mills of three and ten stamps, respectively, which latter have been set up hardly more than a year, and when it is recalled that all the properties are as yet doing little more than development work the outlook is encouraging.

Silver is as yet practically a negligible quantity. All the iron produced comes from one furnace, owned and operated by a native and the methods are of the crudest. The coal industry is still in the first stages, but to judge from the active exploration going on in two districts, next year's figures should show a material increase.

The Igorots of Lepanto-Bontoc manufacture many domestic articles from the copper which they mine themselves. The amount is extremely variable and almost negligible.

There are at present five stamps mills in the Islands—three in Benguet and two in Masbate. The largest has ten stamps of 900 pounds each. One dredge is in operation in the Camarines and one temporarily shut down in Masbate.

Up to June, 1907, 1,601 lode claims and 533 placer claims had been filed; of these, one lode claim has been patented, 14 have been surveyed and are now ready for patent, and six placer claims have been surveyed and are also ready for patent. Three hundred and thirty-eight coal claims have been filed up to the present time, of these 3 have been patented.

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EXHIBITS.

EXHIBIT A.

MINING AND GEOLOGICAL NOTES ON A PORTION OF NORTHWESTERN MINDANAO.

By H. M. ICKIS.

The territory considered in this article lies to the south and east of Makajalar Bay on the northwest coast of Mindanao.

The largest settlement is the town of Cagayan, the capital of the Province of Misamis, which is situated on the right bank of the river of the same name and about 3 miles from its mouth. The recently created subprovince of Bukidnon has taken from Misamis Province nearly all the back country which is inhabited by non-Christians, leaving to Misamis only a narrow strip along the coast, peopled by Visayans. The inhabitants of the interior are harmless and peaceable, they are termed *Monteses* or *Bukidnons* (mountain men). Travel or prospecting can be carried on without molestation.

The low bottom land in the vicinity of Cagayan extends from 1 to 4 miles back from the seashore, where there is an abrupt rise to an elevation of 300 to 500 feet and thence a gradual rise to the southward. The streams flow in a general northerly direction through deep, narrow cañons until they strike the low coastal plains. These cañons are seldom less than 300 and are sometimes nearly if not quite 1,000 feet in depth, the walls being either vertical or very steep.

At a distance this whole region appears to be an unbroken table-land rising gradually from the first elevation of 300 feet or more to 2,600 feet at the divide between the Pulangui, or Rio Grande de Mindanao, which flows south to Illana Bay, and the streams flowing north into Makajalar Bay. However, as the country is traversed, all the small branches of the rivers are found to be engorged.

The practical topographic features are, therefore, first, a low, narrow, coastal plain; then a table-land rising to an elevation of 2,600 feet at the divide, thence sloping gradually down to 1,700 feet and finally dropping rapidly to the valley of the Pulangui at an elevation of 1,100 to 1,200 feet. The table-land extends along the sea from Tagaloon to Iponan, a distance of approximately 20 miles. The eastern limit is marked by Tagaloon and the lower reaches of the Suaga River. On

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the west, the table-land is limited by a range of mountains extending from Mount Kotunlod through Maniqui to Pigtao on the Iponan River, and on the south by Mount Kotunlod and the Pulangui River Valley. A lofty, igneous range of mountains, which includes at least one volcanic cone, lies to the northeast around the headwaters of the Pulangui River. Mount Kotunlod and Mount Kalatungan to the south are volcanoes estimated to be 6,500 to 7,000 feet above sea level; the Malapalay and the Cagayan Rivers rise from between these two mountains, the former flowing southward to the Pulangui and the latter westward to Makajalar Bay. The higher ranges are all wooded, but the table-lands and valleys are grassy with only scattering inyam (*Antidesma*) trees.

The north and west portions of the table-land consist of conglomerate beds which are sometimes capped with limestone; where this limestone appears, smooth grassy hills rise above the surrounding plain and occasionally white cliffs, visible for a great distance, are seen. The conglomerate beds themselves are composed of andesitic and basaltic bowlders, cemented together with material of the same nature.

The table-land at Maniqui, 15 miles south of Cagayan, is terminated by a narrow strip of coral limestone which lies between the conglomerate beds and the igneous range to the southward. Maniqui Creek is a branch of the Iponan River but it rises and flows for some distance very close to the Cagayan. Where it strikes the strip of limestone mentioned above, the water, except in the time of flood, sinks in and follows some underground channel, leaving a dry, narrow cañon with vertical limestone walls. In this limestone area there are many depressions which have no natural surface drainage, but only an underground outlet.

The igneous hills at Maniqui consist of andesite porphyry, but the stream beds show a variety of igneous bowlders among which tough, fine-grained, dark colored rocks predominate. There are also some non-mineralized quartz bowlders and many of pure magnetite.

Washings of the gravel showed a large amount of black sand and occasionally small colors of gold, but it is not probable that placer mining would be profitable in this region. The Monteses wash a small amount of gold from the gravel in the bed of the Cagayan River and from the small swales and gullies in the conglomerate where the elements have concentrated the gold, which doubtless occurs in small quantities throughout the conglomerate beds. The gravel beds of the Cagayan River are extensive and they have never been thoroughly tested. It is possible, but hardly probable, that they contain gold in paying quantities.

Copper has been reported from Maniqui, and several short tunnels have been run in the effort to disclose deposits of copper ore, but apparently without success. Small pieces of the copper carbonates, malachite and azurite, occur as float and in small stringers in the andesite, but it is believed that no lode or deposit of value has ever been found.

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Back of Agusan and Tagaloön, the conglomerate beds are continuous to the Mañgima River which flows into the Tagaloon some 12 miles from the coast.

Between the Mañgima and the Kalaman, another branch of the Tagaloön, is a small mountain composed of schist capped with 300 to 400 feet of limestone. The schist beds strike northeast sloping 15° to 35° to the southeast and the limestone is unconformable with it, but also slopes slightly to the southeast. Many small stringers of quartz are to be seen in the schist, but none were observed more than a foot in width. The quartz is not mineralized.

Gold colors were obtained by washing the sands of the Mañgima, but aside from surface washings no attempt was made to test the gravel. The stream is swift and the gravel contains many large bowlders, so that the working of any deposit on a commercial scale would be difficult. However, there is a possibility that workable veins of gold-bearing quartz occur on the western slope of this mountain.

The table-land of conglomerate beds continues beyond the Calaman, but at the crossing of a small branch of the Atugon River, called Tabalo Creek, the deep-seated underlying rock is exposed. It is a dark colored, coarse-grained porphyry containing phenocrysts of mica and of feldspar up to one-half inch in length. A short distance southeast of this place the Atugon River falls over a cliff 50 to 70 feet high, formed of columnar basalt.

The Suaga River flows through a small cañon of solid basalt at Oroquieta, commonly known as Malaybalay, the capital of the subprovince of Bukidnon. Flow lines, scoriaceaous material, and columnar structure are all absent. Shale appears in the hills about a mile east of Oroquieta. Only basaltic bowlders were observed from Oroquieta to Sevilla on the bank of the Pulangui; but there is little doubt but that the underlying rock is solid basalt derived from Mount Katunlod.

The mountains to the westward of the Suaga and the Pulangui Rivers are of an entirely different character, being rough and irregular in outline and covered with a heavy growth of timber. Mount Panacion, situated 2 miles southeast of Linabo, is composed of andesite-porphyry capped with 300 to 400 feet of unstratified limestone. Limestone cliffs are visible farther to the southeast and from the evidence presented by bowlders in the Pulangui and the appearance of the hills themselves, it is believed that a large part of the territory drained by the headwaters of the Pulangui consists of andesite-porphyry and deep-seated, igneous rocks, overlain in places by limestone.

The gravel beds along the Pulangui River are extensive and so far as could be ascertained they are well adapted to dredging operations. Promising colors were obtained by washing the surface gravel near Sevilla in a gold pan. It is believed that these gravel beds are worthy of careful

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PLATE V. A PROSPECTOR'S CAMP IN MINDANAO.

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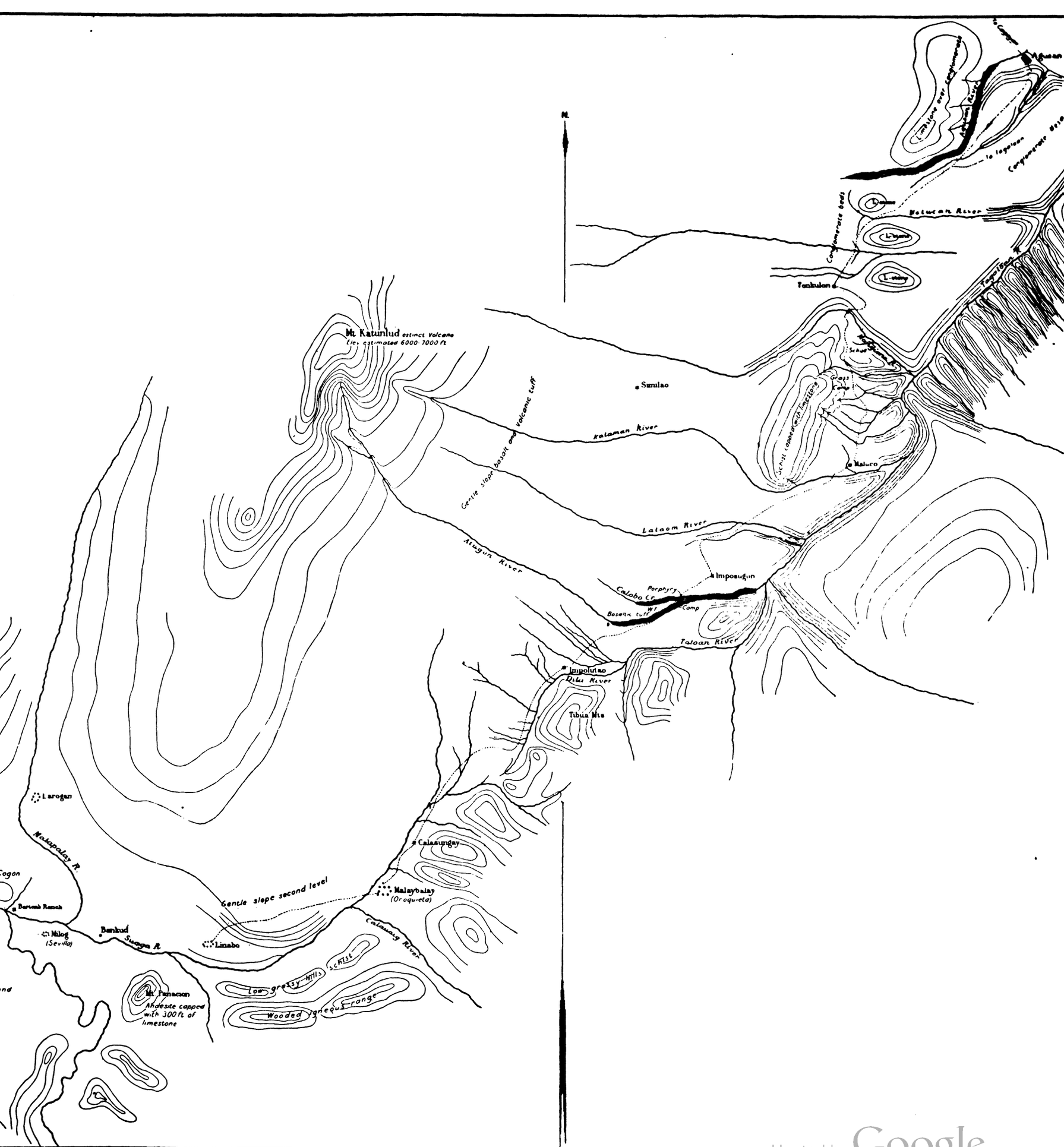

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TOPOGRAPHY

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investigation by prospectors who have testing machines or are equipped to sink test pits.

The headwaters of this river also afford a virgin field, since no prospector or miner has ever been known to visit the region. Gold is known to occur in the river gravels, and the rock is of a nature favorable for the formation of mineral deposits. At the present time transportation is a difficult problem, but it is expected that a wagon road will soon be constructed from Agusan to the Pulangui River.

EXHIBIT B.

MINING PROSPECTS ON AND NEAR THE ZAMBOANGA PENINSULA, MINDANAO.

By WARREN D. SMITH.

BRIEF SUMMARY OF THE GEOLOGY.

Up to the present time we have been indebted to the famous traveler and geographer, Ferdinand V. Richthofen, recently deceased in Berlin, for all we know of the geology of this particular part of the world. Von Richthofen's contribution to the geology consisted chiefly in the finding of nummulitic (Eocene) limestone in a piece of "float" in the neighborhood of Zamboanga. The period and conditions then prevailing in the country made it impossible for him to do more. Owing to even more unfavorable conditions, Mr. George F. Becker, who accompanied General Otis in his military operations in 1898, was prevented from carrying on any geologic studies.

The fact that the writer has been able recently to obtain some new data is due solely to circumstances. The country is at peace and every facility of an extremely efficient military organization has been brought to aid in this work. There are still many obstacles to overcome, but these only time and good government can remedy.

The Zamboanga Peninsula owes its existence to a sharp bowing up of the strata along a northeast and southwest line. Considerable metamorphism is to be found as a result of intense, lateral compression, and therefore it is difficult to give the exact original succession of strata. With the exception of a very pronounced development of schists along the axis of the peninsula, the formations are almost identical with those of the middle and northern portions of the Archipelago.

If, as we have every reason to believe to be the case, the coal measures have been included in the same compressive movements as those which gave origin to the schists, a most favorable condition is at hand for the formation of bituminous coal. The real structure of the peninsula is not revealed until the explorer has penetrated 10 miles or more into

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the interior, as a recent lava capping, which is partially cut away by the streams and which borders the coast, conceals the foundation rocks.

At this stage of mineral exploration in the Zamboanga Peninsula, which may be said to be but scarcely begun, there are only two subjects which warrant mention; these are the Sibuguey coal deposit and the Tumaga gold prospect. I shall discuss the latter first.

Tumaga River gold prospect.—Gold has been found about 25 miles north of Zamboanga. It is encountered in a sticky, yellow clay, the upper, weathered portion of the underlying schists, but apparently only in very moderate quantity. Its original situation was the quartz stringers in the schist. No veins large enough to work have been located. The only apparently profitable method of working such placer ground would be by hydraulic means, and as the city of Zamboanga is at present and probably will for some time to come be dependent upon this river for its water supply, there would undoubtedly be serious objections to this mode of procedure.

Three or four Zamboanga prospectors sluiced very industriously in this region for over a year, but apparently did not secure a great deal to repay them. Prospecting for a main lode should be continued, but placer ground should be sought nearer the mouths of the streams, where dredging might be done. For some time to come all thought of accomplishing much in the interior of the peninsula will need to be given up, owing to absolute lack of roads and to the topographic conditions which will make their building extremely costly.

The Sibuguey coal deposit.—Although not strictly on the Zamboanga Peninsula, the coal deposits on the Sibuguey River are sufficiently close to be considered here. A complete inspection of the deposits could not be made in a short time, but enough was seen to show that exceptionally favorable conditions obtain in this locality, and it is the intention of the mining division to carry on a thorough, detailed examination of this deposit as soon as a party is available. All that can be said now is that for outcrop coal, that of Sibuguey has better appearance than any other so far found in the Archipelago which has been investigated by the division of mines.

Water transportation to the mine mouth, a distance not exceeding 13 miles, is perhaps the next most favorable condition. The topography of the country is very regular and with little relief, and the elevation above sea level not over 150 feet. The seams have a westerly inclination, varying from 23° to 45°. Timber is plentiful in the neighborhood of the workings. Perhaps the least favorable feature is the matter of an anchorage. A more careful survey of the bay may reveal suitable moorings for ships while loading.

It is not improbable, to judge from the nature of the geology of the Zamboanga Peninsula, that a very good bituminous coal will be found

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(Courtesy of Far Eastern Review.)

PLATE VI. FIRST GOLD OBTAINED BY CYANIDE PROCESS IN THE PHILIPPINE ISLANDS.

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nearer Zamboanga, and it is not entirely without the bounds of possibilities that anthracite may one day be discovered. The formation of anthracite is not altogether dependent upon age, but is also largely the result of the degree of metamorphism, the chief factors of which are pressure and heat. It can be seen even from a very cursory examination of the formations, that the metamorphism of the rocks in this region has been very intense.

EXHIBIT C.

SUMMARY OF THE CHIEF CHARACTERISTICS OF PHILIPPINE ORES.

By WARREN D. SMITH.

Up to this time very little has been said concerning the character of Philippine ores, if we except scattered notes and reports. One reason for this is that even now very little is known. In order to present the question in concrete form, I shall briefly state some of the more important features connected with Philippine ore deposits as we now know them. The chief copper ores are those of Lepanto, Luzon. They are sulpharsenates. There appear to be no appreciable amount of sulphides in the workings so far as can be ascertained at the present time. There are indications that the enargite is due to secondary enrichment.

The veins are more or less irregular. The chief gangue mineral is quartz. The gold which comes from this region is probably associated with pyrite, which is present in greater or less quantity. The veins are thought to be due to contraction in the cooling mass of trachyte, where they are now found, and they are not considered to be typical fissure veins.

The gold ores in the Benguet region are partially free milling, but for the most part refractory. The cyanide process is being used at one mine, but there are certain local features which will necessitate slight modifications to suit special conditions. One trouble experienced in amalgamation in both Benguet and Masbate is the presence of oxides of manganese. These cause no inconsiderable annoyance.

The ore relations in both Benguet and Lepanto point to deposition from ascending water and in Benguet several promising properties are located along the contact between the basalt diorite and the andesitic extrusives. It is fully expected that future geologic work in the district will establish some definite relations which will be of very practical value to the mining men. In Benguet, no system of fissuring has so far been worked out and this will be one of the first features of the work to be undertaken there.

However, in Masbate, a very regular series of parallel fissure veins has been noted and these are now being mapped on an accurate topographic map. These veins have a northwest and southeast course across

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the country. They are generally faulted along one contact. Brecciation and later mineralization have been noted as quite common in the district.

We have in the Philippines great quantities of black sand, which is found to contain hornblende, pyroxene, magnetite, ilmenite, rutile, platinum in small quantities, and not inconsiderable percentages of gold. The gold is free, but in so finely divided a state that the method of recovery will be largely a physical one. Experiments are now being carried on here by the chemical division, and in the field some New Zealand operators are studying this material.

Tellurium was identified by this division some time ago. It is said by a reputable engineer of Benguet Province to occur in the characteristic form which it assumes in Colorado; that is, in fine streaks and stringers, irregular in the gangue. There does not seem as yet to be any very important development of this mineral. It is very interesting to note that just adjoining the telluride zone, which is of very limited dimensions, a 2-foot vein of ore assaying as high as $50 to the ton has been observed on one claim.

Silver in particularly noteworthy quantity has not yet been found. Although some free silver is reported from Lepanto, most of the metal which was known in Spanish days came in argentiferous galena.

These are the bald statements of the facts as we now know them. It would be decidedly premature to discuss them more in detail in the present state of our knowledge of the field and its problems.

EXHIBIT D.

SUMMARY OF THE CHIEF CHARACTERISTICS OF PHILIPPINE COALS.

By ALVIN J. COX (*from the Chemical Laboratory, Bureau of Science, Manila, P. I.*).

The subject of Philippine coal is of great importance to these Islands. Although coal occurs so abundantly in this Archipelago, Philippine coal is used only sparingly as a fuel. It has been employed on the small vessels plying along the coast with fairly satisfactory results, but largely owing to the undeveloped condition of the mines and the difficulty of transportation, it has come very little into competition with the coal imported from Japan and Australia. As a result, the development of commercial industries is handicapped by the high price of fuel. In view of this fact efforts have been made to foster coal production in the Islands. Mr. W. D. Smith [2] has made geologic studies of some of the more important coal fields and I [3] have investigated the quality and means of utilization of the coal from as many representative sources as could be obtained.

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[2] *Bull. Min. Bur.*, Manila (1906), 5; *Phil. J. Sc., Sec. A, Gen. Sci.* (1907), 2, 377.

[3] *Phil. J. Sc.* (1906), 1, 877; *ibid., Sec. A, Gen. Sci.* (1907), 2, 41 and 400.

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The oldest and largest deposits of Philippine coal known are on Batan Island, Cebu and Polillo, although coal occurs in greater or less quantity in Negros, Mindoro, Masbate, Samar, Surigao, Zamboanga, Tayabas, Rizal, Lepanto-Bontoc, Nueva Vizcaya, etc.

The Philippine coal deposits resemble those of black lignite, but are superior to the ordinary lignite in every respect. It is rather the exception for these coals to have a brownish color and they seldom show a woody structure. In appearance they are usually black and shiny, much resembling bituminous coal, but generally have a slightly lower calorific value than the latter. On the other hand, they have a much higher calorific value than ordinary brown lignite. The name "sub-bituminous" best describes this coal since it conveys the most accurate idea of its nature and value. So far as is definitely known, all Philippine coals are noncoking. Although I have investigated coals from every available authentic source, not a single sample of coking coal has been found among them. A few samples from time to time have shown incipient coking and recently one said to be from near Cebu, Cebu, has been brought in which gives a coke having the appearance of being of good quality. This may be the beginning of a sufficient supply and perhaps in the deeper beds coking coal may be abundant. The importance of such a discovery will at once be recognized when it is remembered that both iron and copper occur in the Philippines. I have tried to make coke from the incipient coking coal by variously treating it with heavy hydrocarbon compounds, but without success.

The quality of the Philippine coal will be shown by the following representative analyses:

TABLE 1.—*Representative analyses of Philippine coal.*[4]

[Figures give percentages.]

Source.	Moisture.	Volatile combustible matter.	Fixed carbon.	Ash.	Sulphur.
Batan Island:					
Bett's	15.41	39.46	41.01	4.12	0.22
Military reservation	7.44	35.26	44.81	2.49	0.25
Cebu:					
Near Carmen	16.70	35.10	43.92	4.28	0.67
Compostela	8.60	36.95	51.75	2.70	0.71
Danao	9.97	37.94	46.29	5.80	0.8
Polillo	5.90	39.29	48.82	6.00	----------
Negros	15.90	35.44	34.37	14.29	0.99
Mindoro	15.35	46.26	32.24	6.15	----------
Samar	15.24	45.38	36.36	3.02	----------

[4] These analyses were made by the "smoking-off method." (*Phil. J. Sc., Sec. A. Gen. Sci.* (1907), 2, 41.) The empirical methods usually employed for the analyses of coals are not applicable to those of the Philippines, owing to certain peculiarities of the latter. The analyses as carried on by the "official method" (*J. Am. Chem. Soc.* (1899), 21, 1116) indicate Philippine coal to be of a much poorer quality than is actually the case.

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Barring diluents, water, ash, and sulphur, it is surprising what a general uniformity there is in all Philippine coal and this fact suggests, if no other reason were apparent, that it was all bedded under about the same conditions.

How best to utilize the coal deposits of this country is a question which has long attracted attention; however, but little progress has been made toward its solution. I am at present carrying on some actual steaming tests under the boiler with as many coals as are available from representative sources. These, although not in all cases wholly satisfactory, are encouraging. They were all compared with Australian coal purchased by the Bureau of Supply on Circular Proposal No. 248, and used as a fuel by this Bureau. This coal is *"double screened and picked twice."* The contract price delivered at Manila, piled in the coal sheds and yards of the Civil Government is ₱10.75 per ton of 2,240 pounds.

In considering the following data it must be remembered that the samples of Philippine coal were used as they came from the mine and were neither screened nor picked.

TABLE 2.—*Steaming tests of Philippine compared with Australian coal as unity.*

[Figures give percentages.]

	Outcrop coal from Batan Island.	Coal field of Danao, Cebu.	Military reservation, Batan Island.
Theorical heat value as determined in the calorimeter	69	91¾	85¼
Actual steaming value when burned under the boiler	63	84	66
Efficiency from the standpoint of the actual heat value	91	92	77¼

The loss of heat in the use of the Philippine coal was for the greater part through the smokestack, although a certain amount was due to fine coal falling through the grate.[5] The following data will show these facts:

TABLE 3.—*Flue temperature when various coals were burned.*

[Degrees centigrade.]

	Australian coal.	Batan Island coal.	Danao, Cebu coal.	Military reservation, Batan Island coal.
Average	360	440	389	413
Maximum	435	504	454	468
Minimum	330	400	391	385

[5] There is an exception in the case of the sample from the military reservation, Batan Island. This sample had evidently lain in the tunnel since the shutting down of the mine a few years ago and was throughly silted over, whereby the normal ash content of the coal was certainly increased 6 or 7 per cent. It clinkered badly and required much working to keep the grate free.

There was a consequent loss of heat.

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TABLE 4.—*Relative loss of combustible matter in ash.*

	Australian coal.	Batan Island coal.	Danao, Cebu coal.	Military reservation, Batan Island coal.
Percentage of total refuse	13.3	----------	6.1	18.8
Percentage of combustible matter in total refuse	22.32	----------	28.9	36.5
Percentage of combustible matter of coal lost	2.97	*4.5	1.8	6.88

*Estimated.

It has several times been reported to me that Philippine coal burns exceedingly well when mixed with a certain proportion, say 30 per cent, of Australian coal or even slack. This condition would be anticipated. The effect is probably entirely physical. The Australian, which is a coking coal, would help to sinter together and retard the escape of the light particles of the noncoking native coal, until conbustion could be effected in the range of the water heating surface of an ordinarily constructed boiler.

The comparison of the theoretical and the actual ratios in *Table 2* is very satisfactory when all the facts are considered. The fuel was all fired in the gridiron-grate furnace of this Bureau, for which the usual fuel is Australian coking coal; in fact it is especially suited to and designed for the consumption of coal of this class. It is probable that a more satisfactory grate could be used for native coal and I am convinced that a saving would follow by the use of a different style of furnace. Without doubt much can be done in furnace construction by securing the proper firebox and grate to insure more complete combustion of the coal and more perfect abstraction of the heat from the hot gases. A furnace with a short firebox, planned for a high-grade steaming coal which burns with a short, hot, smokeless flame, is entirely unsuited to Philippine coal. The firebox must be greatly lengthened, or else a considerable portion of the fuel value of the volatile combustible matter, which approaches 50 per cent, will be lost.

It is worthy of mention that few of the Philippine coals form clinker, generally they are easily fired and burn well. This was the characteristic tenor of the reports of the officers in charge of the United States Army transports *Chukong*, *Sacramento*, and *Palawan*,[6] when trials were made of the coal from Batan Island.

Granting the usefulness of Philippine coal for steaming purposes there are other points to consider, namely, the economy and the preservation of the supply. In developing, opening up and working the mines there is always a large amount of outcrop coal and slack that is unsuited for steaming purposes and which for sake of economy should be used.

[6] *Bull. Min. Bur.* Manila (1906), 5, 47 et seq.

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Recently experiments with a producer gas plant [7] have given unusually promising results. It was at first thought impossible to use poor coals in a gas producer to develop gas for a gas engine, but lignites worked well and the gas had as high a calorific value as that from any other coal which was used.

Mr. M. R. Campbell,[8] a member of the committee in charge of the producer experiment says: "In every case the power produced by one pound of coal in the producer is many times the power produced by the same amount of coal in the steam plant. The ratios of these results run from 1.96 to 3.34; that is, the very best West Virginia coal yielded practically three and one-third times the amount of power when used in the producer that it did in the steam plant, and the very poorest coal yielded in the producer practically double the amount of power that it did in the steam plant."

The committee in charge remark [9] that a simple engine was used in making the boiler tests. The efficiency of these tests might have been increased by substituting a compound engine: but the fact must not be overlooked that there is even a greater chance of increasing the efficiency by improving the gas engine, which is still new and unperfected.

The gas-producing power of the Philippine coals [10] has been studied and while not always equal to that of American bituminous coal in quantity, the quality is in most cases fairly good. It probably would not be profitable to use these coals in the production of illuminating gas, for usually the most important factor in this process is the by-product, coke.

The report of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904, gives a very pleasing outlook to the possibilities of producer-gas operations and there is probably no doubt but that Philippine coals are most admirably adapted to use in a producer plant. Physically they are ideal to handle. They are noncoking, they do not swell, they burn steadily, form very little clinker, and the ash would easily be removed automatically. Since the quantity of ash in a producer plant is of no material consequence, it seems likely that dirty coal could be used in this way to great advantage. It is also probable that the outcrop coal and slack employed in a producer-gas plant may become as valuable as the best grades of coal used in a steam plant, or perhaps even succeed the steam plant altogether for stationary work.

With a satisfactory scheme for the utilization of the upper and poorer grade of coal, the mines can successfully be operated and the deeper coal

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[7] *U. S. G. S., P. P. 48* (1906), 3.
[8] *Economic Geol.* (1907), 2, 287.
[9] *U. S. G. S., P. P. 48* (1906), 3, 1324.
[10] *Phil. J. Sc.*, (1906), 1, 877.

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can be used for steaming, where a producer gas plant and gas engine are impracticable. For the production of power, the utilization of our low-grade and outcrop coal for producer gas seems extremely promising.

This Bureau hopes to establish a trial plant at no distant date and when it is in operation we can add very definite data to our present information. It is hoped that such a plant can compete with the best steam plant and especially that it can burn successfully the slack and waste products which are not utilizable for steaming purposes.

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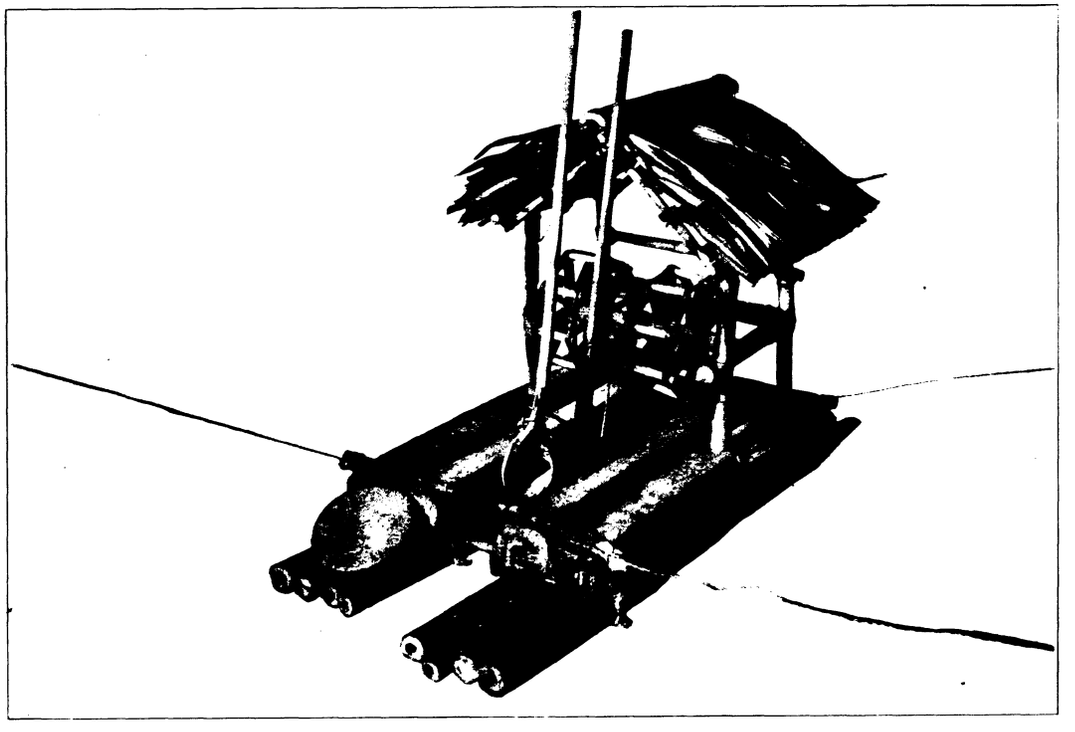

PLATE I. MODEL OF NATIVE DREDGE IN USE IN AMBOS CAMARINES, LUZON.

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DEPARTMENT OF THE INTERIOR
THE BUREAU OF SCIENCE
MANILA

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS

WITH A STATEMENT OF THE PRODUCTION OF COMMERCIAL MINERAL PRODUCTS DURING THE YEAR 1908

ISSUED BY

WARREN D. SMITH, PH. D.

CHIEF OF THE DIVISION OF GEOLOGY AND MINES,
BUREAU OF SCIENCE

MANILA
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1909

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INTRODUCTION.

In 1907 the gold production for the Philippine Islands amounted to only $78,000, which was indeed small, however, it marked only the beginning of the industry. We who were on the ground had faith in the country and what it could produce. It was a different matter with those outside the Philippines to whose ears there came year after year reports of failure. Besides, we had inherited a host of troubles from the days of the Spanish régime. The man to whom we appealed asked not for opinions, not for excuses. He wanted results. We could not point to them then. Therefore, it is with extreme satisfaction that we can now show these results; point to the facts. In 1908 the gold production amounted to over $200,000, a gain of over 100 per cent.

Before our coal deposits were opened up there were many who predicted many difficulties, both in mining and in using the coal. The fact remains, however, that the coal is being mined, mined cheaply, and is being used by over a score of interisland trading vessels. The production at the beginning of 1907 was almost nil, toward the end of the year it amounted to 25 tons a day, at the present time it is 50, and it is planned very soon to increase the output to 150 tons, owing to the fact that a large amount of development work has been done in one of the mines. The Government coal mine is producing at the present time 80 tons a day.

One very regrettable feature about the mining situation in these Islands is the fact that so few of the better class of Filipinos take any interest in the development of the mineral resources of their own country. It is true the semiwild Igorots of north-central Luzon mine and smelt copper on a small scale, and hundreds of natives in various parts of the Islands are engaged in desultory panning for gold. It is also true that the only iron furnace in operation in the Philippines is owned and run by a Filipina woman. With these exceptions, the Filipino people are almost absolutely ignorant about mining and, what is worse, seem to be apathetic in regard to it.

It would be far better for the country politically and industrially if some of the bright Filipino youths who are sent to the United States for education could be induced to take up courses in mining and engineering chemistry, and on their return place themselves as apprentices in some company, beginning with the most menial work. We can not expect the

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Filipino, with his peculiar Malay temperament and past education, to take kindly to this sort of work at first, but we are not without hope that some day he will demonstrate that he can do it.

Many surprises in regard to the Filipino as a laborer have been afforded us. If he can only be protected from the unscrupulous labor leader, he will get along very well.

Our system of collecting mining statistics has this year worked entirely satisfactorily, the mining men coöperating in every way.

Regarding the mining laws there is little new to be said. The bill providing for certain changes, notably in sections 33, 56, and 75, went before the Congress of the United States last year, but was referred to committee and got no farther. It is sincerely hoped it will be revived. In this connection another point should be referred to, namely, the fact that neither the present nor the amended bill provides for any location work. As a result of this oversight there are many good claims absolutely held up by persons who either can not or will not do any work on the properties, and prevent others who might do something from having even an opportunity to do so. It is believed that some provision like that in the Colorado law which requires that "before filing such location certificate, the discoverer shall locate his claim by first sinking a discovery shaft upon the lode, to the depth of at least 10 feet from the lowest part of the rim of such shaft at the surface," would do much to mitigate this evil.

Further recommendations might very appropriately be made at this time, as follows:

First, and perhaps most important, is the crying need for permanent and accurately located monuments on the old mining concessions. It is almost impossible in some districts for newcomers to find out just what land is occupied and what are the boundaries.

Second, we should like to see a Central Miners' Association formed. There are now several local associations for the different districts, any one of which would make a good pattern for the central body. A great amount of good has resulted already from these excellent organizations.

Third, the duty on mining and milling machinery should be removed.

Fourth, the limitations placed upon the shipment of dynamite and powder over the railroads of the Islands, we believe, could be changed materially without risk to the public or to property, and certainly with great benefit to the mining men.

Last, we recommend that the capitalist at home take a little time to look into the field here. Is it not a little to our shame that almost all the capital in the early days came not from America, but from Americans in the Philippines and from New Zealand? The latter, the pioneer dredge-masters of the world, have come here and found it worth while, and continue to come. Surely that is a guaranty.

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In every way the future of the mining industry looks bright. Indeed, we can say that the present is bright. The way by which we have come has at times been dark and stony, many are there who have dropped beside the trail, every milestone is also a tombstone, there have been fevers, the fury of the elements, and lurking savages to worry us, but the march has continued. We sincerely hope that the cry in the wilderness will be answered from overseas.

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THE NONMETALLIC MINERALS.

By WARREN D. SMITH.

FUELS.

Coal.—In 1906 and the early part of 1907 rather vigorous exploration work was being carried on in no less than five coal fields. At the present time this activity has become confined to the narrow limits of one island, Batan, off the east coast of Albay, Luzon. We find here the coal mine of the United States Army on the west end and on the east the Batan Coal Company's property. The former is producing 80 tons per day, the latter 50 tons.

There is a marked difference in the coals of the two fields, the coal of the Army mine on the west end being somewhat better, but more difficult to mine, while on the east end it is just the reverse. Development work has corroborated the prediction made in 1905 that considerable faulting would be found on the west end of the island. This may seriously embarrass the operations there. At any rate, it will call for the most experienced engineering and managing ability. As this work is a matter entirely separate from any civil or private enterprise, I do not feel called upon to discuss the situation further.

An important feature in the growth of coal mining in the Islands is the coaling of the U. S. A. transport *Dix* for her trip to Seattle. During the past year the interisland transport *Wright* has been using this coal with good results, but the *Dix* by taking on 2,500 tons in April marked the first use of Philippine coal on a trans-Pacific steamer.

The East Batan Coal Company's mine is the first one since the American occupation to furnish coal to the general market and the first successful coal property in the whole history of these Islands. This mine was visited in March, 1909, by Mr. H. G. Ferguson, geologist of this Bureau, to whom Mr. Daniels, the superintendent, kindly furnished the information given in this paper.

The property is situated in the eastern part of Batan Island which is just 19 kilometers east of the port of Legaspi in the southern part of Luzon.

For fear that the charge may be made that the Government is advertising private properties, I wish to state that this company is the only private concern operating, and therefore it can not be benefited at

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the expense of any other. Secondly, we do not guarantee the future welfare of the property merely by stating what has been done, nor do we mean to place any official indorsement on the methods employed. Thirdly, we believe in encouraging an infant industry in every legitimate way and, by giving these facts at this stage of the mining industry, we believe we best subserve its interests. There are facts here that are of vital importance to the prospective investor and to the mining engineer who may be sent out to open up new properties.

This mine is located within a few hundred meters of the *barrio* of Batan and approximately 210 meters from the sea. The outside plant in March, 1909, consisted of one 30-horsepower Sedgwood double-drum hoisting engine and boiler. The cars are hoisted from the tunnel and run down by gravity on a small track to the sea, where the coal is loaded into lighters, in which it is conveyed out to deep water beyond the reef to the ship's side. A new wharf, 91 meters long with 7 meters of water at low tide alongside, is nearly completed. A stock pile will be placed about 300 meters from the wharf end and will be located at about 600 meters from the tunnel. Two small steam locomotives are used now.

Coming now to the underground work, the coal seam varies from 1.67 to 1.75 meters, with 7 to 12 centimeters clay parting 55 centimeters from the roof, and dips 13° to the north. The roof is a hard, sandy clay and stands remarkably well with only a slight tendency to slab off in the first half meter.

There are two adits and three air shafts. The system adopted is the room and pillar, with the rooms running up the dip 4.5 meters wide and 90 to 120 meters long, with 15-meter pillars. The coal is sometimes worked 15 meters beyond the timbering. The west gallery is 243, and the main tunnel 198 meters.

Wire haulage is used in the main tunnel, but cars are pushed by hand in the rooms. Rails are soon to be laid right up to the working face.

The coal is easily broken from the face by working up the dip. Coal cutting machines are not required. The coal breaks evenly from the clay and possesses a good cleat. All sorting is done underground. Japanese pickers were originally solely used, but the natives have been trained and have been found entirely satisfactory. They can win from 5 to 7 tons per day. Japanese are now used mainly for timbering and advancing main tunnels.

The scale of wages is as follows:

Japanese foremen	₱2.50
Filipino pickers	1.20
Filipino helpers	1.00
Surface laborers	.80

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PLATE II. EAST BATAN COAL COMPANY TUNNEL.

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There was some difficulty with the labor at first, but now there is none. The Filipino laborers are all Bicols from the surrounding country, and have proved steady workers.

Narra has been found to be the most satisfactory timber available.

Preliminary work was begun in October, 1906, in this mine. The first shipment of coal was 77 tons in the bunkers of the *San Juan*. The production up to date amounts to 15,000 tons approximately. At present only one shift is working, giving a daily output of 45 tons.

In this district only the uppermost seam is being worked. From the general relations which obtain over Southern Luzon and the Visayas, I feel safe in predicting the discovery of at least two more and perhaps considerably thicker seams below this one. I feel confident that the entire eastern end of this island is underlain by workable, merchantable coal.

A good feature in the working of this mine is the absence of dust. Dust has been found to be one of the most potent factors in mine explosions. So large a part does it play that in Europe all dry coal mines are required by law to be constantly sprinkled. Here, of course, this is not necessary.

In order to show in as concise a manner as possible the steaming value of this coal, I reprint here the statements of the engineers of two coast-guard cutters, the *Busuanga* and the *Negros*.

Relative merits of Australian and Batan coal based on tests during two months' use of each, cutters Busuanga and Negros.

	Australian.	Batan.
Miles steamed (two months)	5,662	5,442
Tons coal consumed steaming	229	348
Total cost of coal consumed	₱3,744.15	₱2,088.00
Cost per mile steaming	.66	.38
Cost per 1,000 miles steaming	660.00	380.00

Compared with Australian coal, Batan coal burns freer, requires light and frequent firing, and but little attention. It gives hardly any soot in tubes and connections and little clinker. It disintegrates very rapidly after being spread on fires and quite a percentage is lost if used on coarse grates.

It is seen that about 50 per cent more of the Batan coal is required for a given run, but the cost is just a trifle more than half that of the Australian, so that when bunker space is available a saving can be made by using Batan coal.

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On Cebu Island the mine of the Insular Coal Company was in operation during a part of the year. At present, however, the mine is closed down, though the company is hoping to reopen it in the near future.

1876. Centeno y Garcia, Jose. Ministerio de Ultramar, memoria geológico-minera de las islas Filipinas. Madrid, Tello (1876), **8**, 64. 1 map.

1886. Abella y Casariego, Enrique. Rapida descripción física, geológica y minera de la Isla de Cebu. Madrid, Tello (1886), 187. 5 pls., 1 map.

1890. Abella y Casariego, Enrique. Descripción . . . de la Isla de Panay. Manila Chofre (1890), 203. 2 maps, 1 table.

1901. Becker, G. F. Report on the Geology of the Philippine Islands, *U. S. G. S. 21st Ann. Rept.*, pt. III, 493–614. 2 maps.

Burritt, Charles H. The coal measures of the Philippines. Washington, Government Printing Office (1901).

1903. Wigmore, H. L. Report of the investigation of coal deposits on the Batan Military Reservation, Batan Island, P. I. Washington, Government Printing Office, April (1903).

1905. McCaskey, H. D. 5th Ann. Rept. of the Mining Bureau for the year ending Aug. 31 (1904). Manila (1905).

McCaskey, H. D. 6th Ann. Rept. of the Chief of the Mining Bureau (1905).

Smith, W. D. The coal deposits of Batan Island. *Mining Bureau Bull. No. 5 (1905)*.

1906. Ickis, H. M. Polillo coal deposits. *Ms. Rept.*

Cox, A. J. Philippine coals and their gas-producing power. *Phil. Journ. Sci.* (1906), **1**, 877–902.

1907. Cox, A. J. The proximate analysis of Philippine coals. *Phil. Journ. Sci., Sec. A.* (1907), **2**, 41–65.

Smith, W. D. Nonmetallic minerals. *Far Eastern Rev.* (1907), **4**, 10.

Smith, W. D. Coal in Cebu. *Far Eastern Rev.* (1907), **4**, 14.

Smith, W. D. Mining prospects on and near the Zamboanga Peninsula, Mindanao. *Far Eastern Rev.* (1907), **4**, 184.

Smith, W. D. The geology of the Compostela-Danao coal field. *Phil. Journ. Sci., Sec. A.* (1907), **2**, 377–403. 15 pls., 3 maps.

1908. Smith, W. D. Mining prospects on and near Zamboanga Peninsula, Mindanao. *The Mineral Resources of the Philippine Islands*, Manila (1908), 31.

Cox, A. J. Summary of the chief characteristics of Philippine coals. *Mineral Resources of the Philippine Islands*, Manila (1908), 34.

Ferguson, H. G. Coal in the Cagayan Valley. *Phil. Journ. Sci., Sec. A.* (1908), **3**, 535–537. 1 map.

Cox, A. J. Philippine coals as fuel. *Phil. Journ. Sci., Sec. A.* (1908), **3**, 301–355. 13 pls.

1909. Cox, A. J. Calorimetry and the determination of the calorific value of Philippine and other coals from the results of proximate analysis. *Phil. Journ. Sci., Sec. A.* (1909), **4**, 171–203.

Natural gas.—There has been considerable interest aroused within the last year by the tapping of small reservoirs of natural gas in the course of drilling for artesian water. Two of these cases were investigated by members of the staff of the Bureau of Science and it was found that only a small pocket of gas had been penetrated and that the supply was

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exceedingly small and intermittent. To Mr. Rivers, a well driller in the employ of the Civil Government, I am indebted for the following notes:

Locality.	Struck gas at—	Quantity.	Struck water at—	Quantity.
	Meters.		*Meters.*	*Liters per minute.*
Macabebe, Pampanga, Luzon	36.5	Flash	57.9	283.9
Manalan, Pampanga, Luzon	48.7	do	94.5	283
Sto. Tomas, Pampanga, Luzon	38.1	Flame 3 m. high, burned 15 minutes then extinguished.	67	454.3
San Jacinto, Pangasinan, Luzon	16.7	6 m. high; great force.	[a]	None.
Lingayen, Pangasinan, Luzon	73.15	Flash		
Bay, Laguna	69.5	Small, intermittent flame.	69.5	22.7
Iloilo	47.2	Flash	[b]	

[a] Well cased and driven deeper. Work stopped here. [b] Still sinking.

Peroleum.—Peroleum has been found in five places in the Archipelago—three in Tayabas Province, the other two on the Island of Cebu; one near the center of the island on the west coast not far from Toledo, the other near the southern extremity, very close to the *pueblo* of Alegria. In Tayabas and at the first-named locality in Cebu some prospecting by means of boring has been carried on, but as yet the Alegria field remains practically unknown. The oil in all three of these localities is found in a bluish shale, presumably of Tertiary age. Taking up these prospects in detail we shall consider Tayabas first on account of its proximity to Manila.

In Tayabas Province on the east coast of the peninsula south of San Narciso Mr. Cook drilled a well 21 meters deep and found some oil. This well is in the Vigo River Valley. On the Bayhay River there is another well 40 meters deep, belonging to a different company. In the latter well, which is about 8 kilometers from the coast, the yield at the beginning was reported to be about 190 liters per day. The well has a 5-inch bore and was made with a light churn drill.

While I am not at liberty to publish the entire analysis which was made of a sample sent in by a private person, I can say that the oil appears to be of a very good grade. It has a paraffin base and its composition is very like that of the Sumatran oils.

In Cebu, near the town of Toledo and about 3 miles from the coast and just at the edge of the foothills, are located two wells, the first to be sunk in the Philippine Archipelago. These are located on the sugar estate of Smith, Bell & Co. These wells are sunk in shaley strata (in

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all likelihood similar to the formation in Tayabas) to the depth, respectively, of 244 and 344 meters. Very fair shows of oil have been reported from these wells in former years, but at present all operations have been suspended in the district. In fact, nothing has been done in this field since the outbreak of hostilities in 1897, and when the writer visited the field he found the wells choked up with *abacá* stalks and other refuse material, said by the natives to have been placed there by *insurrectos*. The elevation of the surface at these wells is 23 meters above sea level. There was only one derrick standing. It was approximately 18 meters high, the borings were 3 inches and the casing 6 inches. The strike of the strata is N. 83° W. dip 73° to the south (these figures are taken from the report of the engineer who first examined the field). The drill gear and derrick are from Messrs. Islers, London.

About 2 kilometers from the oil well is an outcrop of coal which in former years was worked to some extent, but now is entirely abandoned. From a hasty reconnaissance of the country it is my opinion that the strata are less disturbed in this portion of the island than on the eastern side of the Cordillera or to the south, in the vicinity of the Alegria oil field. It is the intention of the Division of Mines to undertake a more detailed survey of this region at an early date, with a view to the rapid delimitation of the coal and the oil-bearing horizons.

At Alegria the oil is found at an elevation of 350 meters on the Malbog Creek, about 3 kilometers in a straight line from the coast. At 441 meters a bed of poor brown lignite is found. The strata here dip eastward, or into the island, being quite different from what was found in the Toledo field. The rock capping on the surrounding hills is a coralline limestone of probable Pliocene age. The oil appears to be identical with that from the other two fields and is found oozing out of the same bluish shale. To those intending to explore this field I would recommend that a light drill be taken just over the divide, about 1 kilometer to the east from the place where the oil at present comes to the surface, to a point where the topography reaches its lowest elevation, where the oil-bearing stratum would be found under better cover.

With reference to the likelihood of finding oil on the east coast of Cebu, I might add that although the sedimentary formations are the same, yet a great area of igneous rock which occurs there would cause serious interruption to the oil-bearing formation. The apparent connection between coal and oil deposits in Cebu and other islands of the group leads me to think that in time oil may be found in paying quantities in many parts of the Archipelago.

Analysis of Alegria oil.

Color and odor, good.
Sp. gr. at 27° C., 0.8191.
Boiling up to 150°, 22 per cent, sp. gr.=0.721; 150–300°, 42 per cent, sp. gr.=0.802.
Residuum (solid paraffin), 36 per cent.

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MISCELLANEOUS.

Cement.—For the fiscal year ending June 1, 1908, the total value of cement imported amounted to ₱1,384,000. It has increased yearly. Not a kilogram has as yet been manufactured in the Philippine Islands. We have in several localities all the ingredients and yet the search for gold mines continues, while one of the surest and most profitable business propositions of all is overlooked.

I have repeatedly called attention to Cebu, where shale, limestone, and coal are to be found in abundance. It is true that some of the shale already tested is too low in silica, but with the addition of schist, which is to be obtained in Cebu or imported from Romblon, this would be rectified.

On Batan Island there is an inexhaustible supply of limestone and shale, the analysis of which shows that they are in every way quite well suited to this purpose. Romblon, according to recent examination of Dr. G. I. Adams, geologist of this Bureau, appears to possess materials not so well suited to the manufacture of cement as it was hoped.

1908. Cox, A. J. Volcanic tuff as a construction and cement material. *Phil. Journ. Sci., Sec. A.* (1908), **3**, 391.

1909. Cox, A. J. Philippine raw cement materials. *Phil. Journ. Sci., Sec. A.* (1909), **4**, 211–229.

1909. Adams, G. I. The marble and schist formations of Romblon Island. *Phil. Journ. Sci., Sec. A.* (1909), **4**, 87.

Kaolin.—Kaolin of a fair grade has been found in several localities in the Philippines, the best known deposits being in Laguna Province. A deposit is reported to have been discovered recently near Baguio in Benguet. Two produced this year.

1904. McCaskey, H. D. 5th Ann. Rept. Mining Bureau (1904), 35.

Phosphate.—In nearly every extensive cave in the Philippines a dirty, coarse, granular soil is encountered, varying from a few centimeters to more than a meter in depth; this is usually a bat guano, the quantity varying from only a few tons to several hundred. It can be handled profitably when several caves are found close together. The Island of Marinduque has many such caves, one of which is estimated to contain 500 tons. I believe the only people in the East who handle guano very extensively are the Japanese.

In Ilocos Norte very small pockets of apatite crystals have been discovered, but the mineral has not been found in commercial quantities. The finding of much phosphate rock anywhere in the Philippines is, in my opinion, not probable, as these deposits usually occur on rainless, oceanic islands or on islands which have been more or less arid at some time in their history.

Sulphur.—Since our last year's report we have investigated the sulphur supply on Mount Apó, but regret that the locality does not

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offer very much. In the first place, there is very little in sight, a half dozen small solfataras with a few tons deposited around them, and, secondly, the peak of Mount Apó, whereon these solfatares are located, is so difficult of access that it would not pay to try to exploit the sulphur.

1884. Abella y Casariego, E. La Isla de Biliran (Filipinas) y sus azufrales. Madrid, Tello (1885), 15. 1 pl. (map). Also in *Boletin de la Comisión del mapa geológico de España* (1884), 11.

1907. Goodman, M. Sulphur in the Philippines. *Far Eastern Rev.* (1907), **4**, 120–121.

1907. Ferguson, H. G. The sulphur deposits of Camiguin Island. *Far Eastern Rev.* (1907), **4**, 152–153.

Salt.—The occurrence of springs flowing hot saline solutions, either quite saturated or nearly so, appears to indicate the existence of natural salt deposits in the Philippines, although none has been actually encountered. Such springs are known to exist at Mainit near the town of Bontoc, at Asin near the boundary line between Lepanto and Nueva Vizcaya, and near the town of Bambang in Nueva Vizcaya. All of these occurrences are in the interior of northern Luzon and at least 35 miles from the coast.

Asbestos.—Prospecting in the serpentine area of Ilocos Norte, where some of the poorer grade of asbestos has been found, has discontinued and therefore we have nothing new to state with regard to this mineral.

Manganese.—Development work continues on the manganese prospects near Point Blanca, Ilocos Norte, but as yet there has been no noteworthy shipment of the ore. Near the Aroroy gold mining district on the Island of Masbate, manganese ore occurs, apparently as lenses in a red slate. Development work, however, has not progressed far enough to ascertain whether the deposit is of any importance.

1907. Smith, W. D. Notes on economic geology of Ilocos Norte. *Far Eastern Rev.* (1907), **3**, 334.

1907. Smith, W. D. The asbestos and manganese deposits of Ilocos Norte, with notes on the geology of the region. *Phil. Journ. Sci., Sec. A.* (1907), **2**, 145.

Mineral spring waters.—In last year's bulletin a list of all the chief mineral springs was given. This year we are able to give some figures showing the enterprise of the owners of two of these.

Of the three prominent resorts in the Philippines two are located at mineral springs, one at Los Baños on Laguna de Bay where from forty to fifty guests can be accommodated, and the other is at Sibul Springs, where sixty people are staying in the hotel. Besides, there are numerous families living in cottages.

At Los Baños it is estimated that 263,440 liters of the water were sold in 1908 and at the Sibul Springs 5,000.

Artesian wells.—Artesian wells have been sunk throughout the Philippines. These are largely located in the great plain of Luzon where the

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formation is to a great extent volcanic tuff in which are intercalated marine sands. The Bureau of Public Works has drilled a large number of wells and has demonstrated that artesian water can be found at rather shallow depths at many points in the central plain of Luzon, and following the lead of the Bureau of Public Works various municipalities have drilled good artesian wells with ordinary jet drills.

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THE METALLIC MINERAL RESOURCES OF THE PHILIPPINES.

By HENRY G. FERGUSON.

GOLD.

As may be seen from the table of statistics, the gold production of the Philippines for the year 1908 shows an extremely satisfying increase over that of 1907. In two out of the three principal districts there are mining companies which have successfully passed through the development stage and are now preparing to pay dividends. Everywhere development work is being carried on and, owing to the courage of the first pioneers, capital has begun to flow a little more freely. Those conditions which have held back investors from putting money into any Philippine industry, apply with particular force to mining, for in most cases, the investor in an undeveloped mining property must wait for several years before he can expect any returns, and he must therefore be doubly certain of the safety of his investment. It is idle to deny that under more favorable conditions the present prosperous state of the gold-mining industry might have been reached before this.

Masbate.—Of the three principal gold-mining districts of the Islands, Masbate alone shows a falling off in production. This is due, not to any inherent defect in the district itself, but to a variety of causes.

Of the three stamp mills in the district, one 5-stamp mill was found to have been poorly designed and therefore unsuited to the work required. It was dismantled two years ago. Neither of the two 10-stamp mills has been in operation during the year, one being idle on account of litigation and the other awaiting the reorganization of the company.

The district has suffered heavily from typhoons during the past year, the centers of no less than three passing near the mining district. The Lanang Dredging Company was a particularly heavy sufferer, as, besides having its houses and offices blown down, the dredge was wrecked and the pontoon badly damaged, though fortunately the machinery was uninjured. The accident was particularly unfortunate as it came just as operations, after two years of preliminary work under disadvantages which would have permanently discouraged many others, had finally reached a stage where substantial returns were to be expected. It is gratifying to report that this dredge is to be rebuilt.

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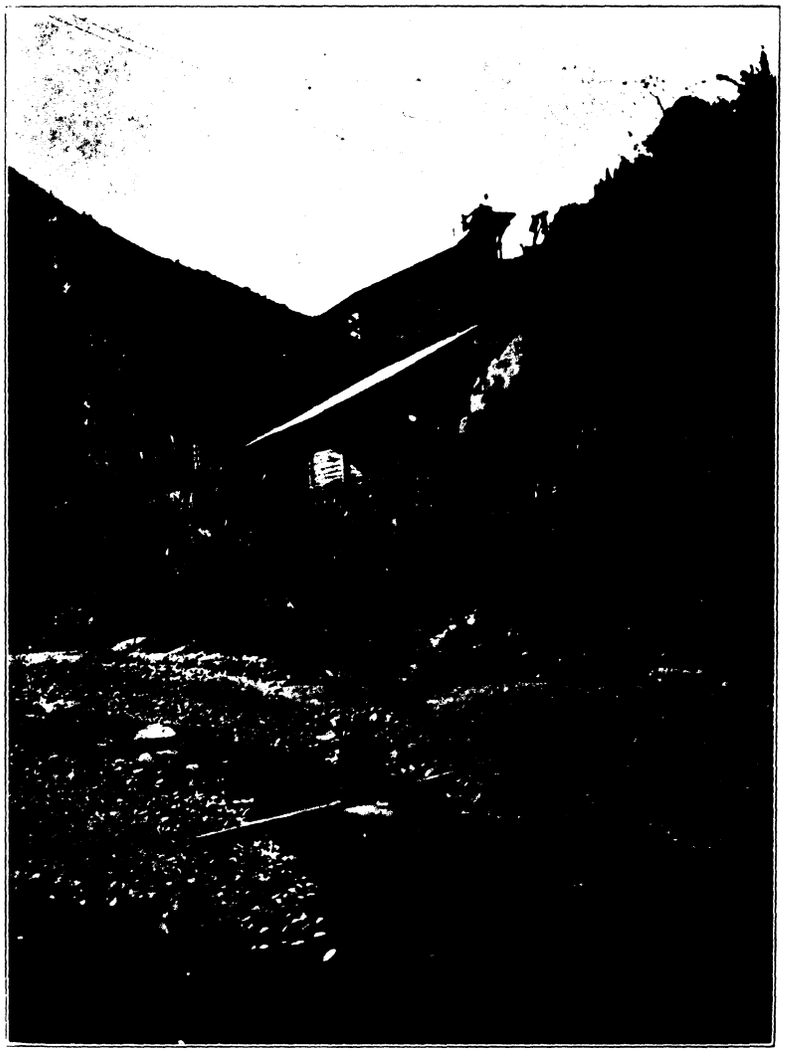

PLATE III. BUA MILL, ANTIMOK, BENGUET.

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In lode mining, continued development work is showing up large and easily worked ore bodies. The ore is not as a rule of high grade, but natural conditions of the district are so favorable that mining costs should be cheaper here than elsewhere in the Islands.

The chief development work of the year has been done by the Keystone Mining Company on Aroroy Mountain where the two shafts have been connected at 20 meters below surface by a drift at present 85 meters in length and a tunnel has been driven from the southwest side of the mountain a distance of 70 meters. The Colorado and Eastern mining companies have both done considerable development work during the past year with very satisfactory results, the former in developing its vein system by continuing its tunnels and the latter by cutting a vein which is said to show 15 meters of workable ore. Both these companies expect to go ahead on a much larger scale during the coming year. Besides these, various individual miners have been doing steady development work, though of course, as is nearly always the case, they are greatly hindered by lack of funds.

As regards the district as a whole there has been a general realization that more extensive development work is needed before production is attempted. Therefore reorganization on a more businesslike basis is succeeding the period of depression which was the natural result of absurd overconfidence.

The district has further been benefited by the construction of a road from the village of Aroroy to the Guinobatan River. A light-house has been erected on Punta Colorada opposite Aroroy, allowing vessels to enter the harbor at night, and the harbor has been buoyed. The steamer service from Manila is better than ever before. During the year 1909 it is planned to extend the road up the Guinobatan River, through the heart of the mining district, to connect Aroroy with Masbate by telegraph, and to establish a money-order post-office at Aroroy; all of these small public improvements being things which the district needs and deserves.

Paracale.—The Paracale district in the northern part of Ambos Camarines was regarded by the Spaniards as the most important mining region in the Islands, and the mines have been worked intermittently and the streams washed since before the days of the Spanish conquest, and the hills are honeycombed with ancient workings.

Since the American occupation development has been hindered by the confusion which has existed in regard to titles, there being great uncertainty as to the validity and extent of many of the Spanish concessions. Lately, however, satisfactory arrangements have been made in many cases, and work is progressing.

The Paracale district consists of maturely eroded hills of metamorphic and igneous rocks containing quartz veins. The large plains of the Paracale and Malagit Rivers as well as smaller valleys afford very

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promising dredging ground, which is now being thoroughly prospected, chiefly by means of small drills, showing excellent returns. The Paracale Dredging Company has had a dredge in operation on its property near the town of Paracale for the last year and a half, and such excellent results have been obtained, that several other dredges will be in operation in a short time on neighboring properties. The placer ground in the vicinity of Paracale generally consists of about 4 to 5 meters of barren clay mixed with vegetable matter. In places this overlies a few centimeters of coral, and below this is a varying amount of gray clay carrying values. Beneath this again is an irregular amount of extremely rich sand and quartz pebbles, the latter often showing large amounts of free gold. The gold brought up by the dredge now working is remarkably angular and often shows distinct crystalline structure. The quartz pebbles are often sharp and angular, showing that they have traveled but a very short distance. The bed rock appears to be a schistose rock, decomposed to a clay, which is easily cut by the dredge buckets, making it possible to secure practically all of this rich gravel.

The dredge at present in operation is of the New Zealand type and differs from those generally used in America in that it has no stacking ladder and no quicksilver is used in the riffles. According to the dredgemaster's reports, during a period from May 25 to December 31, 1908, 50,244 cubic yards were handled and 2,814.1 ounces of gold, having a value of $50,653.80, recovered.

Dredging is made difficult not only by the large amount of barren clay which must be removed but the unusually large percentage of fine material handled, about 80 per cent of all the material passing through the screens. The black sand carries values and is saved for future treatment, as is also part of the gray clay. The oversize material from the revolving screen is sorted by hand and the quartz pebbles saved for future crushing.

Two more dredges are now (March, 1909) in course of construction. One of these was formerly in operation on the Guinobatan River in Masbate and has been transferred to Paracale, where it is being rebuilt. The other is of the New Zealand type of construction, both screen and stacking ladder being dispensed with, and all material falling directly from the tumbler to the tables. In March, 1909, the pontoon for this dredge was almost completed.

The dredge now in operation has 38 buckets of 137 liters capacity besides 3 grab hooks. The dredge from Masbate, 45 buckets of 102 liters capacity each, and the third dredge, under construction, 43 buckets of 142 liters capacity.

In regard to lode mining less has thus far been done under the American régime than might have been expected. This delay, however, is due in great measure to the early confusion and uncertainty in regard to titles. At the present time the two principal mines of the district,

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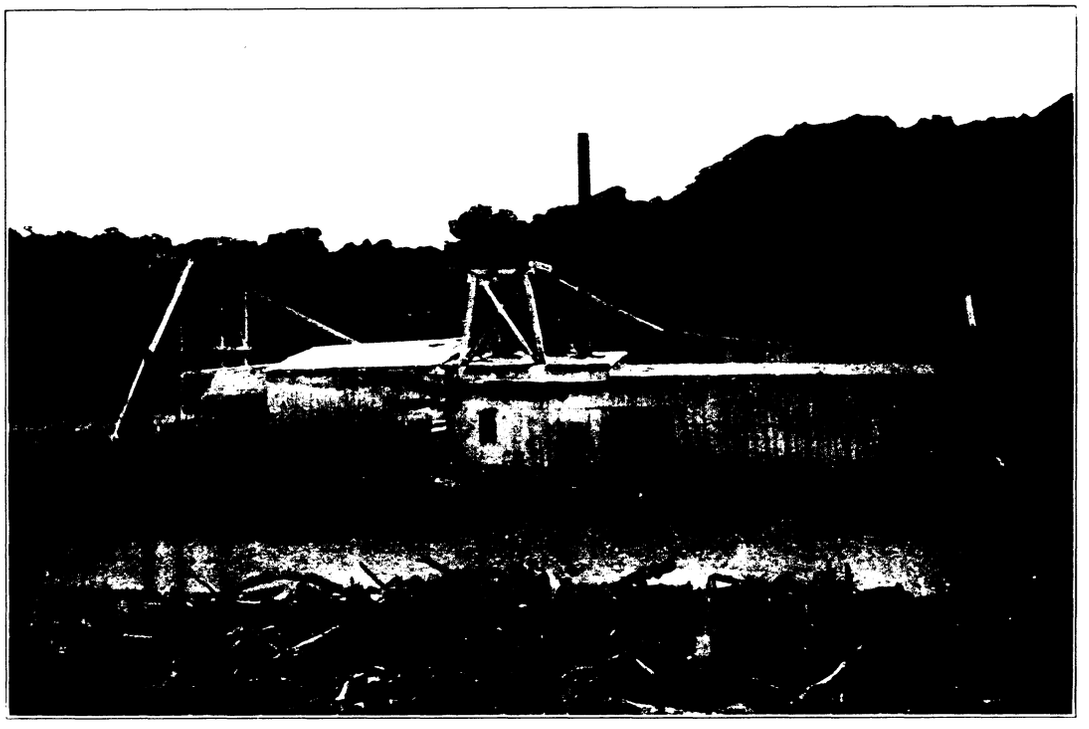

PLATE IV. DREDGE ON THE PARACALE RIVER, CAMARINES, LUZON.

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the San Mauricio and the Tumbaga, both of which were formerly the property of the Philippine Mineral Syndicate, have been taken over by American capital. At the San Mauricio mine the old workings have been retimbered to permit of a detailed examination of the property, work has begun on sinking a shaft, and a 20-stamp mill has been brought out.

On the Tumbaga property the old workings have been unwatered and preparations made for continuing the sinking of the shafts. A Huntington mill, formerly the property of the old company, will be used for treating the ore.

There are many other groups of claims, such as the Mescla group near Mambulao, the Navotas group between Mambulao and Paracale, the San Antonio veins near Paracale, and the claims of the Aurora Exploration Company near Malagit, all of which have been worked to a greater or less extent in earlier times, which it is now proposed to reopen.

During the present year there are several improvements planned for the district aside from the mining work. The most important of these will be the removal of a reef which obstructs the entrance to the Malagit River, thereby affording excellent harbor facilities. At present there is no shelter nearer than Mercedes on the one hand and Mambulao on the other, and during bad weather the regular steamers can go no further than Mercedes, some 30 kilometers down the coast.

Other improvements planned for the district are the building of a telephone line and the construction of a wagon road from Indang. The Paracale Mining Association has engaged the services of a doctor for the camp. The association also hopes to secure from the Insular Government some arrangement which will permit of having a resident mining recorder. At present there is unnecessarily great delay and confusion caused by the necessity of sending all papers to Nueva Caceres, the capital of the province.

Benguet.[1]—The Baguio mining district still holds its preëminence as the principal mining region of the Islands, and during the past year work has gone steadily forward. The Consolidated Mining Company possesses a 6-stamp Hendy mill, three stamps of which were added during the past year, and a fairly complete and modern cyanide plant. The mine is worked from four tunnels having a total length of over 900 meters with about 100 meters of cross-cuts. Some stopes have been opened up, but the company has wisely confined its attention almost entirely to development work, which has furnished sufficient ore for the mill. During the past year two agitators have been added for treating slimes and have greatly facilitated the treatment as well as increased the extraction. The company has installed a Wilfley table to treat the sands

[1] For information in regard to Benguet and Lepanto the writer is indebted to Mr. Maurice Goodman of this division, who visited the district in February, 1909.

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from the classifiers, thereby still further increasing the capacity of the plant.

The Bua Mining Company has over 600 meters of drifts, about 150 meters of cross-cuts, and a 30-meter raise. Approximately 1,500 cubic meters of ore have been removed by stopes. The ore is treated in a Hendy 6-stamp mill and a cyanide plant, similar to that of the Consolidated Mining Company.

The Camote mine is opened up by tunnels at four levels, having a total length of over 250 meters. The ore is crushed in a small stamp mill made by Taylor in Manila. There are three 340-kilogram stamps run by a 5-meter overshot wheel with a hemp rope drive. The capacity is about 10 tons per day.

On Gold Creek, Mr. Kelley's group of claims has been developed by about 570 meters of tunnels, cross-cuts, and drifts, showing up large bodies of ore. Of particular interest is the discovery of rich telluride ore on the Naptang claim.

The Headwaters Mining Company was organized during the past year and has so far run three prospect tunnels in ore of 18, 33, and 12 meters length.

The Government is now replacing the suspension bridges on the Benguet Road with steel girder bridges. This will be a great boon to the mining industry of this district as it will allow the transportation of heavier machinery than has hitherto been possible. Road building has been progressing satisfactorily. The Government, with the assistance of the Benguet Mining Association, is building a wagon road from Baguio to Antamok, and the miners have received Government assistance in the construction of local mine roads.

Arrangements have been made with the Civil Hospital at Baguio whereby 40 centavos per month is deducted from the wages of the miners and 20 centavos from the Igorot surface workers, in return for which the mine workers receive hospital treatment at Government expense.

Other districts.—The Aroroy, Paracale, and Baguio districts are the only places in the Philippines where gold mining has been carried on to any extent. In other parts of the Islands vigorous prospecting has been going on, and the coming year may show much in the way of developing new districts.

In Suyoc, on the boundary between the subprovinces of Benguet and Lepanto, prospecting and some development work is going on, but the comparative inaccessibility of the district delays development. The district of Binanlonan, Pangasinan, is being prospected, though the deposits have not as yet been developed to any extent. In Nueva Ecija a certain amount of sluicing has been carried on and small amounts of gold are obtained from native washings, but unfortunately we have no returns as to the amount of gold extracted. In the Catanduanes Islands and in northern Mindoro prospecting of placer grounds is progressing. In the Surigao

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peninsula prospecting is being carried on by Americans, and a considerable amount of gold is washed from the streams by natives.

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1876. Centeno y Garcia, José. Memoria geológico-minera de las Islas Filipinas. *Boletin de la Comisión del Mapa Geológico de España.* Madrid (1876), **3** (Gold, 226–230).

1879. Abella y Casariego, Enrique. Memoria acerca de los criaderos auríferos del segundo distrito del departamento de Mindanao, Misamis. *Boletin de la Comisión del Mapa Geológico de España.* Madrid, Tello (1879), **49**. 5 pls.

1883. Abella y Casariego, Enrique. Ligera reseña de la minería de las Islas Filipinas. Madrid, Tello (1883), 15 (Gold, 4–6).

1899. Day, D. T. Mineral resources of the Antilles, Hawaii, and the Philippines. *Eng. Mag.* (1899), **17**, 242–251.

Hermann, R. Besuch im Golddistrict von Camarines Norte. *Globus*, Braunschwieg, Vieweg (1899), **73**, 11–12.

1901. Becker, G. F. Report on the geology of the Philippine Islands. *U. S. G. S., 21st Ann. Rep.* (1901), pt. III, 493–614 (Gold, 576–584).

Nichols, J. C. Notes on the Pigholugan and Pigtao gold region, Island of Mindanao. *Trans. Am. Inst. Min. Eng.* (1901), **31**, 611–616.

(Describes occurrence of gold veins and placer deposits.)

1905. McCaskey, H. D. Fifth annual report of the Mining Bureau for the year ending August 31, 1904. Manila (1905).

(Gives summary of the mineral resources. Gold, 27–29.)

McCaskey, H. D. Sixth annual report of the Chief of the Mining Bureau for the year ended August 31, 1905. Manila (1905).

(Gives summary of developments of year, 16–17.)

1906. Smith, W. D. Preliminary geological reconnaissance of the Loboo Mountains of Batangas Province. *Phil. Journ. Sci.* (1906), **1**, 617–631. 1 map.

(Study of geology of the region.)

1907. Chase, T. Minerals in the Philippines. *Eng. & Min. Journ.* (1907), **83**, 852–853.

Eveland, A. J. Eastern Mining Company's Masbate workings. *Far Eastern Rev.* (1907), **3**, 330–333.

(Detailed description by the superintendent, of the company's property and mining methods employed.)

Eveland, A. J. Notes on the geology and geography of the Baguio mineral district. *Phil. Journ. Sci., Sec. A.* (1907), **2**, 207–233.

(A study of the general geology of the district with detailed map on scale of 1:24,000.)

Goodman, M. The Island of Marinduque. *Far Eastern Rev.* (1907), **3**, 365–366.

(Notes on geology and gold prospects.)

Goodman, M. Metallic mineral resources. *Far Eastern Rev.* (1907), **4**, 12.

(Summary of mining. Gold, 12–13.)

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1907. Goodman, M. Gold placers of Nueva Ecija. *Far Eastern Rev.* (1907), 4, 88.
(Notes on the geology and a description of operations.)
Goodman, M. History of placer mining in the Camarines. *Far Eastern Rev.* (1907), 4, 16.
(A short history of operations, with notes on the geology.)
Ickis, H. M. Camarines gold fields. *Far Eastern Rev.* (1907), 4, 56–57.
(Notes on the geology and a description of operations.)
1908. Ferguson, H. G. The Aroroy Mining District, Masbate. *Far Eastern Rev.* (1908), 5, 56.
(Short summary of the geology and mining.)
Goodman, M. Metallic mineral resources. *The Mineral Resources of the Philippine Islands.* Bureau of Science, Manila (1908), Gold, 22–23.
(Summary of mining work for the year 1907.)
Ickis, H. M. Mining and geologic notes on a portion of Northwestern Mindanao. *The Mineral Resources of the Philippine Islands.* Bureau of Science, Manila (1908), 28–31, with map.
Smith, W. D. Statistics of production. *The Mineral Resources of the Philippine Islands.* Bureau of Science, Manila (1908), 26.
Smith, W. D. Summary of the chief characteristics of Philippine ores. *The Mineral Resources of the Philippine Islands.* Bureau of Science, Manila (1908), 33.

Besides the above papers, the Far Eastern Review in its number for June, 1907 (vol. 4, No. 1), published reports of the operations of various mining companies, and during the past two years special correspondence relating to Philippine mining has appeared from time to time in the columns of the Mining and Scientific Press, (San Francisco) the Mining Journal (London), the Australian Mining Standard, the Far Eastern Review, and the Philippines Free Press.

COPPER.

Another year has passed with practically no production of copper, in spite of the important deposits existing in the Islands.

The Mancayan copper mines in Lepanto have been visited by a representative from a large company in the United States, but unfortunately no satisfactory arrangements could be made as regards price. It is reported that recent development work has shown the existence of ore in the lowest level of this mine, thus contradicting the statement on page 51 of Bulletin No. 4 of the Mining Bureau. The Division of Mines hopes soon to be in a position to confirm this report. The Lepanto Mining Company had been granted a franchise to construct a railroad from the mines to the coast, but this has been allowed to lapse. Assessment, prospecting, and some development work is being carried on on other claims in the vicinity. A good road with fairly low grades is now being built from the coast at Tagudin, to Cervantes, and Baguio is being connected with Cervantes by another road which will pass through Suyoc and Mancayan. The construction of these roads will be of immense

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advantage, as the lack of transportation facilities has greatly hindered the development of this district, which will now have two outlets to the coast.

In Masbate prospecting has been carried on in the newly discovered copper district northeast of the town of Milagros. The felsitic rock carrying native copper has been found to extend over a considerable area and 500 kilograms of picked specimens of this rock which were shipped to a smelter at Tacoma showed, besides copper, very gratifying returns in gold and silver. This deposit of native copper was known to the Spaniards and prospecting has been carried on intermittently since the beginning of the last century.

More promising, however, is the new field discovered by Mr. Brobst about 6 kilometers to the southeast of the native copper deposit. Here there is a series of several small veins, some of copper sulphides carrying values in gold and silver and others of silver-bearing galena. These veins have not as yet been opened up to any extent, but prospecting and development is being carried on vigorously.

Copper ores are also known to exist in the Provinces of Ilocos Norte, Pangasinan, Ambos Camarines, and Batangas on the Island of Luzon, on the Island of Marinduque, and in the subprovince of Bukidnon and the Province of Misamis on Mindanao.

References to copper deposits of the Philippines:

1862. Santos, José Maria. Informe sobre las minas de cobre de las rancherías de Mancayan, Suyoc, Bumucan y Agbao en el distrito de Lepanto. Press of the College of Santo Tomas, Manila (1862), 72.

1876. Centeno y Garcia José. Memoria geológico-minera de las Islas Filipinas. *Boletín de la Comisión del Mapa Geológico de España, Madrid* (1876), 3, (Copper, 221–226).

1881. Hernandez, Antonio. Report on copper in the district of Lepanto (in Spanish). *Revista Minera,* Madrid (1881), 2, 112–118.

1901. Becker, G. F. Report on the geology of the Philippine Islands. *U. S. G. S., 21st Ann. Rept.* (1901), pt. 3, 493–614.
(Summary of geologic knowledge up to the time of American occupation. Copper, 584–590.)

Rinne. Kupfereiche Sande im Malaguitgebiet bei Paracale. *Ztschr. f. prak. Geol.* (1901), 387.

1905. Eveland, A. J. A preliminary reconnaissance of the Mancayan-Suyoc mineral region, Lepanto, P. I. Bull. No. 4, Mining Bureau, Manila (1905).
(A study of the geology of the region, with abstracts from earlier reports. A detailed map of the district on a scale of 1:4,800 is published as Bull. No. 5 of the Mining Bureau.)

McCaskey, H. D. Fifth annual report of the Mining Bureau for the year ending August 31, 1904. Manila (1905). (Copper, 29–30.)

McCaskey, H. D. Sixth annual report of the Chief of the Mining Bureau for the year ended August 31, 1905. Manila (1905). (Copper, 16.)

1906. Lehlbach, L. Mancayan-Suyoc mines and Abra River placers, Lepanto-Bontoc. *Far Eastern Rev.* (1906), 3, 168–170.

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1907. Chase, T. Minerals in the Philippines. *Eng. & Min. Journ.* (1907), 83, 852–853.

Goodman, M. Island of Marinduque. *Far Eastern Rev.* (1907), 3, 365–366.

Goodman, M. Metallic mineral resources. *Far Eastern Rev.* (1907), 4, 12.

1908. Goodman, M. Metallic mineral resources. *The Mineral Resources of the Philippine Islands.* Bureau of Science, Manila (1908). (Copper, 23–24.)

SILVER AND LEAD.

Practically all the gold won in the Islands contains a small percentage of silver, but silver ore is of comparatively rare occurrence. On Mr. Brobst's claims, near Milagros, Masbate, are several veins of galena showing high values in silver and small amounts of gold. Native silver is found in the subprovinces of Benguet and Lepanto near the boundary line. Silver-bearing galena also occurs in Cebu, Marinduque, and Ambos Camarines, but none of these deposits have as yet been developed.

References to silver and lead deposits of the Philippines:

1886. Abella y Casariego, Enrique. Rápida descripción, física, geológica y minera de la Isla de Cebú. Madrid, Tello (1886). (Reference to galena, 146.)

1901. Becker, G. F. Report on the geology of the Philippine Islands. *U. S. G. S., 21st Ann. Rept.* (1901), pt. 3, 493–614. (Silver, 590–591.)

1905. McCaskey, H. D. Fifth annual report of the Mining Bureau for the year ending August 31, 1904. Manila (1905). (Lead and silver, 30.)

1907. Goodman, M. Island of Marinduque. *Far Eastern Rev.* (1907), 3, 365–366.

IRON.

Practically nothing new has been accomplished in the iron industry during the past year. There are large deposits of excellent iron ore in the Provinces of Bulacan and Rizal, but the difficulties of transportation, the lack of native coking coal, and the general feeling of insecurity concerning all things Philippine has prevented the incoming of sufficient capital for production on a large scale, while indifference and ignorance on the part of the native population have prevented exploitation in a small way. The only mine which has been producing during the past year is the Hizon mine at Angat, Bulacan. This mine is operated by a Filipina woman, Doña Maria Fernandez, the only person of her race who has thus far taken sufficient interest in mining to become a mine operator.

Undeveloped deposits of hematite are also known to exist in Ambos Camarines and Marinduque, and a deposit of chrome-iron ore has recently been discovered in the Province of Surigao.

References to iron deposits in the Philippines:

1903. McCaskey, H. D. Report on a geological reconnaissance of the iron region of Angat, Bulacan. Bull. No. 3, Mining Bureau, Manila (1903). (History of the iron industry and account of reconnaissance, with analyses of ores, 62 pp. 1 map.)

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1905. Goodman, M. Report on the Bulacan iron industry. Sixth annual report of the Chief of the Mining Bureau, Manila (1905), 48–56.
(Contains estimates of the cost of production and annual output.)
McCaskey, H. D. Fifth annual report of the Mining Bureau for the year ending August 31, 1904. Manila (1905). (Iron, 29.)

OTHER METALS.

The sulphide ores in the Philippines are as a rule fairly free from zinc, which will be an important factor when the time comes for shipping concentrates to smelters. In several ores, however, varying amounts of zinc blende have been found. Specimens of molybdenite have been obtained in Ambos Camarines and Batangas, and small specimens of stibnite from Batangas and Surigao. There is a constantly recurring rumor in regard to small amounts of native mercury in the vicinity of Mount Isarog, Ambos Camarines, but no definite information can be obtained. No tin has been discovered in the Philippines.

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STATISTICS.

[Compiled by H. G. Ferguson.]

TABLE I.—*Mineral production in 1907.*

Source.	Gold.	Silver.	Copper.	Iron.	Coal.
	Grams.	*Grams.*	*Kilos.*	*Met. tons.*	*Met. tons.*
Albay					4,123
Ambos Camarines	3,110	218			
Bulakan				396	
Mountain Province[a]	[b]120,917		[c]		
Sorsogon (Masbate)	17,167	2,364			
Total	141,194	2,582		396	4,123

TABLE II.—*Mineral production in 1908.*

[NOTE.—For stone, sand, etc., see Table I, under Structural Materials, p. 49.]

Source.	Gold.	Silver.[d]	Copper.	Iron.	Coal.
	Grams.	*Grams.*	*Kilos.*	*Met. tons.*	*Met. tons.*
Albay					9,248
Ambos Camarines	[b]108,000	6,000			
Bulakan				96.5	
Cebu			[c]		787
Mountain Province	[b]209,500	65,800			
Sorsogon (Masbate)	1,000	400	91		
Surigao	8,400	900			
Total	326,900	73,100	91	96.5	10,035
Value in pesos[e]	434,500	[f]2,750	52	17,500[h]	77,166

TABLE III.—*Production of gold and silver by Troy ounces.*

Source.	Gold.		Silver.[d]	
	1907.	1908.	1907.	1908.
Ambos Camarines	100	3,470	7	190
Mountain Province	[b]3,888	[b]6,740	[g]	2,120
Sorsogon (Masbate)	552	30	76	10
Surigao		[b]270		30
Total	4,540	10,510	83	2,350

[a] The former Provinces of Benguet and Lepanto-Bontoc have now been combined as the Mountain Province.

[b] Including estimate of native production.

[c] Small production of copper by Igorots.

[d] Except in the case of Sorsogon (Masbate), the silver production is an estimate based on the amount of gold.

[e] One peso equals 50 cents, United States currency.

[f] Value of silver calculated at ₱0.0376 per gram.

[g] Not given.

[h] This value is for manufactured iron implements.

Equivalent English measures are: 1 gram = 0.32 oz. Troy; 1 kilogram = 2.20 lbs. avoirdupois; 1 metric ton = 1.102 short tons = 0.984 long ton.

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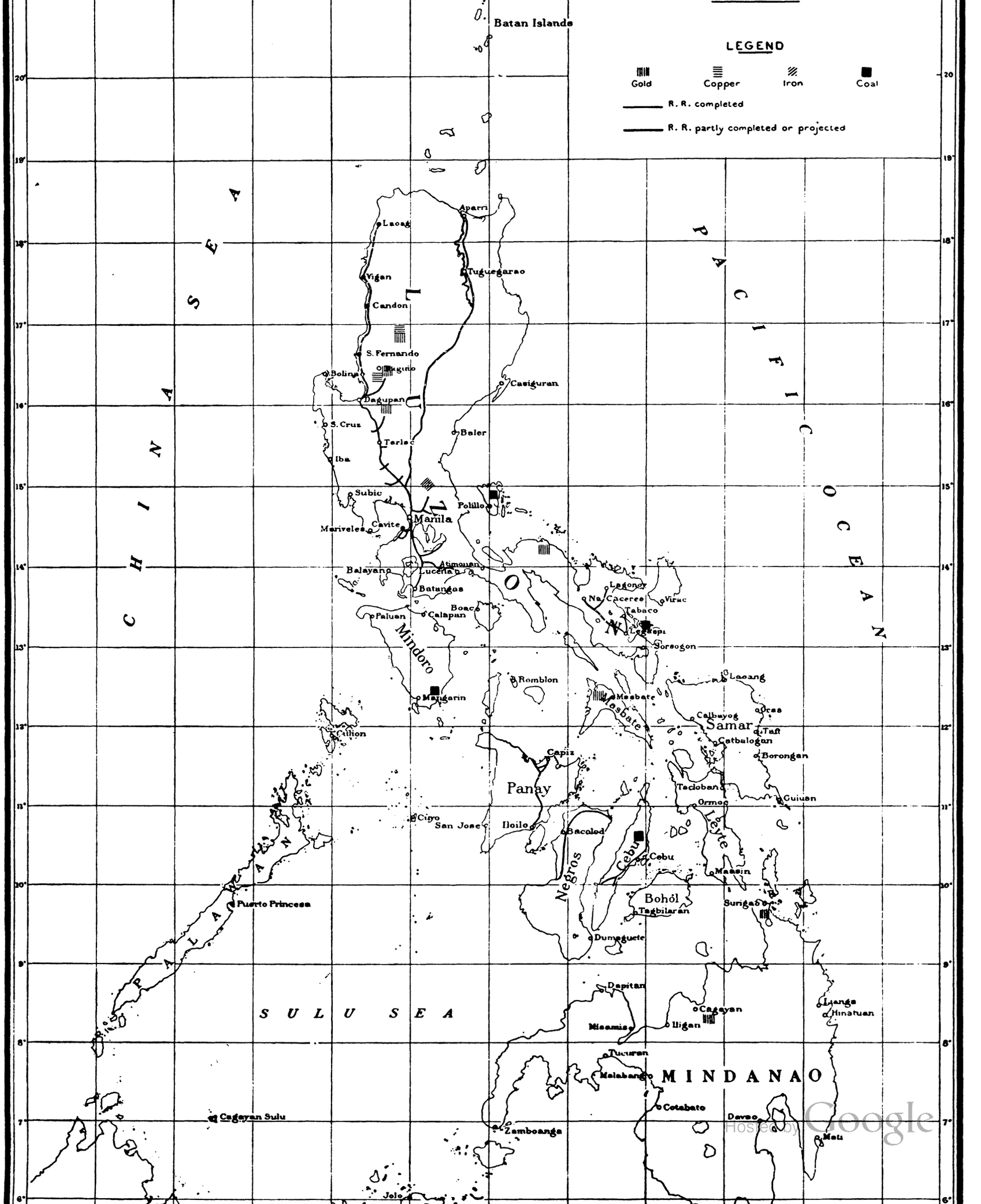

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The magnificent increase in gold production needs no comment, and indications seem to be that next year we shall have the pleasure of recording an equally large increase for the present year. The figures given for silver are believed to be fairly accurate, but as the miners receive no returns for the silver content in the bullion sold to the banks, and hence can not report their individual production of this metal, it is impossible to give a strictly accurate figure.

In conclusion, the thanks of the compiler are due to the various miners who have furnished the figures and made this compilation possible. It is hoped that any miner who through oversight has not received a card requesting information or has not received a copy of this publication will send his name and address to the Division of Mines, in order that his name may be placed on our mailing list. It is our desire to make each succeeding number of this bulletin of greater value to the miners of the Philippines, and in order to do this, we depend entirely on the coöperation of the miners themselves.

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PHILIPPINE RAW CEMENT MATERIALS.[1]

By ALVIN J. COX.

(From the Laboratory of Inorganic and Physical Chemistry, Bureau of Science, Manila, P. I.)

Portland cement consists of silicates and aluminates of lime in certain proportions. It is produced by burning a finely ground artificial mixture of chalky and clayey materials at a sufficiently high temperature for chemical combination to take place. During the burning, which is carried on in kilns of special design and lining, as the temperature approaches 1600° C. the clayey material becomes fused. Pure chalk or limestone (calcium carbonate) does not fuse, but is converted into lime which is taken up by the alumina and silicic acid of the clay, provided that the raw materials have been ground sufficiently fine for an intimate contact between the particles of the components. The product of the burning is a semifused mass called clinker. The lumps of clinker are pulverized and the resulting fine powder is Portland cement.

The essential constituents of Portland cement are calcium oxide (CaO), silica (SiO_2), and alumina (Al_2O_3), or some other flux such as ferric oxide which, similarily to alumina, is able to promote the union of silica and lime. These are all very abundant and in different forms are widely distributed in many kinds of rocks. Calcium oxide does not occur in nature in the free state but in combination as calcium carbonate (limestone, chalk, etc.). Silica and alumina are found in the form of minerals such as quartz and corundum, but in this form they are not suitable for the manufacture of cement, owing to the difficulty of grinding the materials to a sufficiently fine state to cause them to combine with lime; therefore, combinations of these oxides occurring as silicates of alumina, termed clay or shale, are the chief source of these constituents in the raw materials used in cement manufacture.

The majority of limestones contain some clay, and clays often contain a certain amount of lime; these facts are taken into account in proportioning the raw materials. Magnesium, not to exceed 3 or 4 per cent of the finished product, may replace calcium in Portland cement without deleterious results, and iron in any amount may replace alumina.

[1] For a more detailed discussion of this subject, see *Phil. Journ. Sci., Sec. A* (1909), 4, May, 211.

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A certain amount of iron acts as a flux, lowers the fusion point of the mixture, and promotes the combination of the calcium oxide and silica.

Several articles have recently appeared in the literature advocating the superiority of cement for use in sea water in which practically all of the alumina is replaced by iron and showing that iron-ore cement has been used with efficiency for such works of construction.[2]

Limestone occurs abundantly on nearly every island of the Philippine Archipelago and in this region is unformily remarkably pure. The maps of the Batan Island [3] and the Danao-Compostela [4] coal districts show the great extent of the limestone in these localities. In the following table, I give the analyses of limestones from various regions.

TABLE I.—*Analyses of Philippine limestones.*

[In most cases the results given below are the average of two or more analyses and are therefore fairly representative.]

Constitutent.	Source of sample.				
	Mount Licos, Cebu.	Batan Island.	Rombion.	Near Pilar, Capiz.	Near Dumalag, Capiz.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica (SiO)	0.38	0.97	0.10	0.72	0.21
Alumina (Al_2O_3)	0.18	0.56	0.17	0.51	0.17
Ferric oxide (Fe_2O_3)	Trace.	0.36	Trace.	0.31	0.71
Lime (CaO)	55.62	53.86	55.23	54.08	54.42
Magnesia (MgO)	0.00	0.19	0.45	0.99	0.41
Soda (Na_2O) and potash (K_2O)		0.16			
Loss on ignition	43.50	43.18	43.80	43.98	43.84
Water (H_2O) below 110°	0.17	0.30			

When limestone approaches a composition of about 75 per cent calcium carbonate and 20 per cent of clayey matter (silica, alumina, and oxides of iron), it is commonly known as natural cement rock because it contains as impurities approximately the amount of clay material that must be added to pure limestone in making cement. It is very seldom that cement rock is found where nature has done the proportioning so well that it is unnecessary to add any extraneous material, but the more nearly a limestone approaches this condition, the less that will be required. To produce cement from this material it is necessary to add limestone or shale or clay according as the ratio of calcium carbonate to clayey matter is low or high.

Shaly limestone is usually softer than the pure limestone ordinarily

[2] Newberry, S. B., Cement age, 4, 38; Monthly Consular and Trade Report (1908), June, 165; *Cement & Eng. News* (1908) 20, 112, 168.

[3] Smith, W. D., *Bull. Min. Bu.* (1905), 5.

[4] *Idem, Phil. Journ. Sci., Sec. A.* (1907), 2, 405.

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used with clay or shale and is therefore much more easily ground. Other things being equal, raw material approaching natural cement rock can be a little more cheaply prepared for burning than a mixture of pure limestone and shale.

I have analyzed two samples of rock from a cut of the railway near Danao, Cebu, which approach cement rock. They are as follows:

Constituent.	1.	2.
	Per cent.	*Per cent.*
Silica (SiO_2)	29.00	24.02
Alumina (Al_2O_3)	11.38	7.49
Iron oxide (Fe_2O_3)	5.35	2.00
Calcium oxide (CaO)	26.25	33.88
Magnesia (MgO)	0.65	2.12
Alkalies (K_2O and Na_2O)	1.98	
Loss on ignition	23.00	28.25
Water (H_2O) below 110° C	3.84	(a)

[a] Included under loss on ignition.

Neither of these is ideal and would require considerable recomposing to produce a good cement. Since a certain amount of recomposing is always necessary and very little thought need be given to the supply of limestone, I think the source of the raw materials for cement in these Islands will be from the limestones, schists, clays, and shales rather than cement rock.

Entirely suitable shales or clays for the manufacture of a high-grade Portland cement are not extremely abundant. In the Danao-Compostela, Cebu, region, large quantities of clay and shale are to be found. W. D. Smith [5] has mapped these together with the coarse gray sandstone under one color (the coal measures) and estimates the total thickness as 90 to 150 meters. The dip of the beds is the same as that of the coal, which is 20° or more. Some of the outcrops of the siliceous materials are obliterated by covers of talus, others may be followed all the way up the mountain side, whereas still others have been uncovered or more exposed by railway cuts and mine drifts. Data regarding the clays, shales, and sandstone of this region are given in Table II.

It will be seen by referring to any of the military records of drill holes made when prospecting for coal on Batan Island with a standard diamond 2-inch core drill that the holes penetrate thick layers of grayish-blue shale, separated by more or less thin layers of calcareous shale and limestone. It was thought that if they contained the proper constituents these shales might be mined after the manner adopted by some successful cement companies now operating, or quarried somewhere on the island where they are accessible. Analyses of three samples,

[5] *Phil. Journ. Sci., Sec. A.* (1907), 2, 390.

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taken from a drill hole made at an elevation of 6 meters in the Moncao basin on the left bank of the river about 1.5 kilometers from its mouth, show that the materials are of the same general character. The analyses are given in Table II.

A large formation of schist occurs on the Island of Romblon. This is so high in silica that it is doubtful if it could be combined with the marble found at Romblon for the manufacture of cement, but a small amount of material of this nature could successfully be employed for recomposing an ordinary clay or shale base. A typical analysis of this material is given in Table II.

The first two regions named are well located with respect to the local coal districts, and for all of the above localities water transportation is easily available.

TABLE II.—*Philippine shale, clay, sandstone, and schist.*

[Figures give percentages.]

Constituent.	1.	2.	3.	4.	5.	6.	7.	8.	9.
Silica (SiO_2)	60.17	43.38	58.35	44.35	72.76	42.72	35.02	34.80	80.12
Alumina (Al_2O_3)[a]	22.65	29.44	24.11	20.26	15.58	17.23	13.98	12.65	12.56
Iron oxide (Fe_2O_3)[b]	4.66	0.48	9.08	4.64	1.42	6.70	6.01	6.55	1.15
Calcium oxide (CaO)	0.31	9.50	0.80	11.37	0.62	11.12	17.44	17.19	0.12
Magnesia (MgO)	1.85	0.61	2.22	2.59	Trace	3.65	2.84	2.84	0.48
Alkalies (K_2O Na_2O)	.....	1.56	.....	.....	.....	2.31	1.97	2.26	3.69
Loss on ignition	6.35	10.75	8.72	14.30	3.53	15.58	17.50	17.19	1.94
Water (H_2O) below 110° C.	(c)	5.30	(c)	(c)	1.84	1.85	5.31	4.90	0.21

[a] Includes titanium oxide (TiO_2) and possible phosphoric anhydride (P_2O_5).
[b] Total iron determined as ferric oxide.
[c] Included under loss on ignition.

DESCRIPTION OF SAMPLES.

1. Clay from near Comansi, Danao-Compostela region, Cebu.
2. Clay from under the Danao coal.
3. Shale dried at 105° C., Danao-Compostela region.
4. Calcareous shale from railway cut, Danao-Compostela region.
5. Sandstone which outcrops above the coal at the Compostela mine.
6. Shale from Moncao basin, Batan Island drill hole, depth 1.8–48.1 meters.
7. Shale from Moncao basin, Batan Island drill hole, depth 57.2–61.8 meters.
8. Shale from Moncao basin, Batan Island drill hole, depth 114–133 meters.
9. Average of two analyses, agreeing fairly well, of independent samples taken from the schist formation near Romblon, Romblon.

In recomposing raw cement material the limits which may be used are that for every part by weight of silica 2.60 of calcium oxide are required, for every part of alumina 1.10 of calcium oxide, for every part of ferric oxide 0.70 of calcium oxide. The amount of magnesia present is equivalent to 1.4 its weight of calcium oxide.

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The calculation of a cement mixture from clay No. 1, Table II, and the Mount Licos limestone, Table I, would be as follows:

Clay.

60.17×2.60=156.44 parts calcium oxide required by silica in 100 parts clay.
22.65×1.10= 24.92 parts calcium oxide required by alumina in 100 parts clay.
4.66×0.70= 3.26 parts calcium oxide required by ferric oxide in 100 parts clay.
184.62 parts calcium oxide required by 100 parts clay.
0.31+(1.85×1.4) = 2.90 parts calcium oxide equivalent to calcium and magnesium in 100 parts clay.
(1) 181.72 parts calcium oxide to be added to 100 parts clay.

Limestone.

55.62+(0.0×1.4) = 55.62 parts calcium oxide equivalent to calcium and magnesium in 100 parts limestone.

0.36×2.60=0.94
0.18×1.10=0.20
0.0 ×0.70=0.00
} = 1.14 parts calcium oxide in 100 parts limestone which is not available.
(2) 54.48 parts calcium oxide available in 100 parts limestone.

Cement mixture.

$\frac{(1) = 181.72}{(2) = 54.48} = 3.335$ parts limestone required by 1 part clay.

The limestone and clay No. 1 combined according to this calculation give the following results:

TABLE III.

[The figures give parts of the materials by weight.]

	Total.	Individual constituents.					
		Silica (SiO_2).	Alumina (Al_2O_3).	Iron oxide (Fe_2O_3).	Calcium oxide (CaO).	Magnesia (MgO).	Volatile (CO_2, H_2O, etc.)
Clay (No. 1)	100	60.17	22.65	4.66	0.31	1.85	6.35
Limestone	333.5	1.27	0.60	----------	185.49	----------	145.64
Burned	281.5	21.83	8.26	1.65	66.00	0.66	----------

It will be noticed from the parts by weight (percentage composition) of the burned product that the content of lime is higher than that of the average Portland cement which is about 60 to 63.5 per cent.

The results of the formula represent the maximum of lime which a cement can carry, if it were manufactured under ideal conditions. In actual practice these are seldom met with, and it is therefore necessary to carry the lime lower than that indicated by the formula. Furthermore, the method of calculation given above does not give entire satisfaction, since there are two undetermined variables. Limits for the

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silica-alumina (respectively iron oxide) ratio must be set. There are many experiments to show that the percentage ratio of silica to alumina in the clay must be from 3:1 to 4:1 or 2.5:1 to 3.5:1. A richer clay than this will have a lower overburning temperature and will necessarily carry less lime, which makes a poorer cement.

There is every reason to believe that clay No. 1 would produce a better cement if silica in some shape were added to the clay base. With the increase of the silica content at the expense of alumina a safer cement would be produced in that the overburning temperature would be increased. The state of subdivision of the free silica in the raw materials used for this purpose is an extremely important consideration. The sandstone which outcrops above the coal at the Compostela mine (No. 5, Table II), although high in silica, is not suited for this purpose in that it is composed of oxides of iron and alumina and quartz grains so large as to be unsuited to cement manufacture. Tests show this sandstone, which contains approximately 73 per cent silica, to contain over 65 per cent free silica. Indeed tests are unnecessary to prove that the greater part of the silica is crystalline, for the quartz grains are visible to the naked eye. The grains are very loosely held together and can be broken apart by rubbing between the fingers or gently in a mortar. The state of subdivision will be seen from the following table:

Size of sieve.	Meshes per centimeter.	Passed.	Not passed.
100	40	45	55
80	32	57	43
60	24	76	24
50	20	94	6
40	16	98½	1½

The Romblon schist (No. 9, Table II) ought to be satisfactory for recomposing the clay base. It is not improbable that highly siliceous materials, similar to those in Romblon, occur along tectonic lines, and if so, then possibly a similar schist more available to Cebu might be found on some of the smaller islands lying nearer to it. In fact, schists have been found on Cebu itself. These occur, and outcrop only in a few places, along the Cordillera under the capping.

The calculation of the recomposition of clay No. 1 with schist No. 9 so that $\frac{\text{silica}}{\text{alumina (resp. iron oxide)}}=3$ is as follows:

Clay No. 1.—$22.65+\left(4.66\times\frac{102.2}{159.8}\right)=25.63$ parts alumina equivalent to alumina and iron oxide in 100 parts clay.

$$\frac{60.17}{25.63}=\frac{\text{silica}}{\text{alumina}}=2.346$$

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Schist No. 9.—$12.56+(1.15\times\frac{102.2}{159.8})=13.30$ parts alumina equivalent to alumina and iron oxide in 100 parts schist.

$$\frac{80.12}{13.30}=\frac{\text{silica}}{\text{alumina}}=6.025$$

For any given intermediate ratio, parts of each must be combined inversely in proportion as the found ratio varies from that desired. For a ratio of 3:1 therefore, 0.654 (i. e., 3—2.346) parts of schist would need to be combined with 3.025 (i. e., 6.025—3) parts of clay, or a mixture of 82.25 per cent $\left(\frac{3.025}{3.025+0.654}\right)$ clay No. 1 and 17.75 per cent $\left(\frac{0.654}{3.025+0.654}\right)$ schist No. 9, would be required.

Accordingly, a new siliceous material would be obtained as follows:

TABLE IV.

[The figures give parts of the materials by weight.]

Material.	Per cent.	Individual constituents.					
		SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Loss on ignition.
Clay (No. 1)	82.25	49.50	18.62	3.84	0.26	1.52	5.23
Schist (No. 9)	17.75	14.23	2.23	0.20	0.02	0.09	0.38
Total	100	63.73	20.85	4.04	0.28	1.61	5.61

The calculation of a cement mixture from this recomposed clay base and the limestone would be the same as outlined above for clay No. 1 and the Mount Licos limestone. In like manner each clay or shale of which the analysis is given in Table II can be recomposed and combined with limestone to produce a raw cement mixture. Cements could probably be satisfactorily produced from many of the siliceous materials and the limestones near the coal fields, but I am of the opinion that it would be found necessary to add silica to most of these materials in some shape to produce a wholly satisfactory cement.

FUEL FOR BURNING CEMENT.

The composition of the ash of the coal has not been considered in preparing the above figures, but the relative proportions of the raw constitutents may be varied to include this factor, which is not a large one.

The chief combustible for firing cement kilns is powdered coal of the bituminous variety. It must contain the proper quantity of volatile combustible matter to render it easy of ignition at the proper height in the cylinder in order to produce the maximum temperature at the right

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point. The coal must be thoroughly dried, usually by rotary driers heated by hot air from the clinker coolers, before it can be ground to a sufficient degree of fineness. Care must be exercised that the temperature does not rise sufficiently to expel volatile combustible constitutents of the coal. It is of especial importance to consider the available Philippine coals from the point of view of their usefulness as a fuel for cement burning. In the United States, the Fairmont coal has been considered above all as a fuel for burning cement. Its calorific value when calculated to the dry coal is about 7,900 calories. Other coals of less calorific value have been satisfactorily used as a fuel for burning cement. The Philippine coals when calculated to the dry coal would have approximately the calorific values shown below:

Source.	Calories.
Batan Island, Betts's	6,000
Batan Island, Military Reservation	6,800
Cebu Comanal	7,100
Polillo	6,800
Australia	6,800

While the fuel value of the Philippine coals is not as great as the well-known gas coal of Fairmont, West Virginia, these coals appear to be as good under these conditions as many at present in use and as any at present available in the Philippines or neighboring regions, and I am of the opinion that they will be very useful as a fuel for burning cement.

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THE GOLD FIELDS OF THE SURIGAO PENINSULA, MINDANAO.

By MAURICE GOODMAN.

In the barrio of Tinabingan on the west coast of the Bay of Placer, lives a small community of Filipinos. Tinabingan is chiefly known in the Province of Surigao for its former activity in gold washing. Old and abandoned tunnels, shafts, and ditches evince the fact that this industry at one time must have engaged a great number of people. Today the only mining work done by the native population still remaining consists in the washing of the black sands on the beach. One American miner lived and worked at Tinabingan at the time of my visit there. Working absolutely alone, and with but small capital at his command, it is not at all surprising that this one man could show but a very limited amount of development work done, particularly as he had been unfortunate in losing a large part of his work as a result of slides and caves.

The country rock of this region is andesite, intersected by a system of veins, running in general about N. 55 E. and dipping 60°–70° toward the southeast. Many of these veins are mere quartz stringers less than 1 centimeter in thickness. In general the walls of these stringers have become silicified to a greater or less extent, making the limits of the mineralization very indefinite.

About 7 kilometers northeast of Placer is the small Island of Campiña, where at one time comparatively extensive mining work was carried on. On the southern end of the island, about 60 meters from the beach, is the mouth of the main tunnel which is about 5 meters wide and about 10 meters long. This tunnel is intersected by several short drifts, running in all directions and at all inclinations, and now generally caved and in a dangerous condition. The walls of the workings are mostly covered with a clay gouge and no distinct vein can be observed anywhere. It is possible that here, as in Tinabingan, the natives had discovered comparatively rich but very narrow stringers of quartz, and had followed them until the values had petered out, or else the abandonment was caused by the flooding of the workings, for the floor of the main tunnel is only about 3 meters above sea level, and the lower workings were flooded at the time of my visit. Numerous samples were taken from

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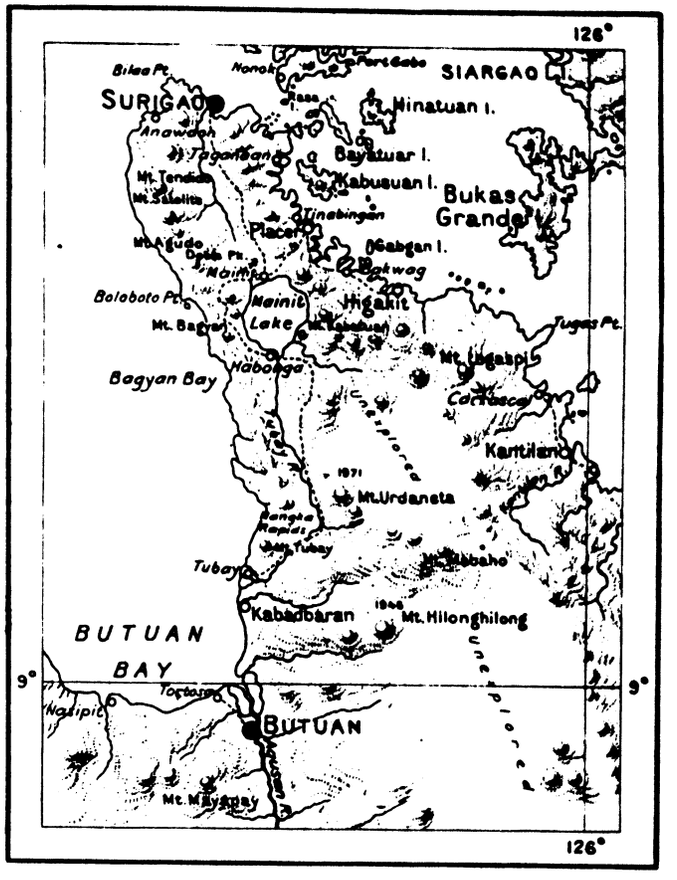

SURIGAO PENINSULA, MINDANAO

Kilometers

10 5 0 10 20 30 40 50

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what appeared to be the most probable pay streaks, but the assay results are so extremely low that the wonder is that even the natives could have found this mining profitable or sufficiently encouraging to have done as much work as they have.

About 16 kilometers south of the town of Surigao, at the head of the Causuran and Biga Creeks, both tributaries of the Surigao River, exists an old placer district that has been worked by Spaniards and Filipinos for a long but an indefinite period of time. Many of the wealthier families in and about the town of Surigao possess heirloom nuggets, some as large as a twenty-dollar gold piece, which were obtained in the Surigao gold fields in bygone days. At the present time but few people are engaged in this business continuously, and these, working on a small scale and with the crudest facilities, make but little more than a living from their operations. Causuran Creek, from its junction with the Biga its source at Mount Binutong, everywhere shows signs of old workings in the form of excavations, ditches, and ground sluices. Great quantities of large boulders, generally chloritized or serpentinized, and smaller ones consisting almost entirely of quartz, are to be found in the bed of the creek. The banks of the creek are mostly slate, striking approximately N. 66° W. and dipping at varying angles but usually toward the northeast. Going toward the south or head of the creek, the slate becomes more and more altered by chloritization and folding, with the development of prominent and important cleavage planes.

The benches that are worked are as a rule situated 10 to 30 meters above the creek, and the gravel, which appears to be the result of surface disintegration and erosion of the country rock, consists mostly of chloritic schist, this being also the base rock of the ground sluices.

The system of working is about as follows: One, two, or more streams of water are turned on the bench which is to be worked, and this washes the finer stuff into the ground sluice. The larger boulders are moved by hand, and are used for building the foundation of the retaining walls for the finer waste gravel. No artificial riffles are used or needed in the sluice. The wash water is brought from the nearest gulley or from some upper workings, by means of 1 or 2 meter lengths of bark troughs, 6 or 7 centimeters in diameter. This water is allowed to play on the gravel for four or five days, during which time the laborers assist the breaking up of the gravel with short crowbars, and by the removal of the large boulders by hand.

Usually on the last day of the week, the ground sluice is cleaned up. First the lower part of the sluice is cleaned out and opened up so as to afford sufficient grade and clearance for the gravel. The water is allowed to run free on the bank and no new dirt is washed. The fine sand and gravel in the sluice is then thoroughly worked up with crowbars, short wooden paddles, hemispherical coconut shells, and with the bare feet. The coarser stuff is picked up in the shell, partially washed

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and drained through a hole in the shell which serves also as a finger hold, and then thrown to the top of the waste pile. The very finest and lightest sand and slime passes down the sluice, leaving nothing but the heaviest sand including the gold. The bed rock itself is scraped up with the aid of crowbars to the thickness of 1 or 2 centimeters.

As soon as the water runs clear over the bottom, panning is begun, the start being made at the face of the bank nearest the water spout and continued down the sluice 6 to 8 meters or until no more colors are obtained. Where there is too much water or it is too dirty, the women splash the water to get a clearer view of the bottom. The women are very expert in the use of the *bilingan* or wooden *batea*, and this process could hardly be improved upon, but in the handling of their waste rock there seems to be much room for improvement. By the use of a giant or even a good hose, a great deal more dirt could be handled and with greater convenience than is being done at present. The bark troughs lie directly on the bench to be washed, and the water passing through the trough comes into immediate contact with the gravel and merely washes over it, thereby losing a great deal of its initial force of impact. To handle the gravel after it is washed, modern picks and forked shovels would be a decided improvement over the paddle and coconut shell, particularly if used in connection with plank staging for heights greater than 2 or 2½ meters.

The gravel is about 2½ to 3½ meters deep, while the waste gravel bank is usually about half a meter higher. It is estimated that about 8 per cent of the gravel is over 0.6 meter in diameter, some of the largest boulders being as much as a meter through their longest dimension. About 30 per cent of the gravel is estimated to be from 0.05 to 0.6 meter in diameter and the remainder is pebbles, sand, and fine material.

Numerous igneous boulders are to be found in the gravel, and the origin of these is acredited to Mount Canmahat, a prominent conical hill arising from the valley of the Surigao River near the head of Causuran Creek, to an elevation of about 180 meters above the creek. This hill has all the appearance of a small extinct volcanic cone; the summit and upper slope are composed entirely of andesite, but about 100 meters below the summit the underlying shale appears. Curiously enough the upper courses of the underlying shale both at Canmahat and the neighboring hill Binutong, are less chloritized and otherwise altered than the deeper seated shale. Gravel washing begins at a depth of 40 to 50 meters below the contact of the shale and andesite. The igneous boulders are usually more numerous than those of the schistose variety, and generally lie above them, the latter evidently being more nearly in place.

Gold can be panned from the surface down, but the colors obtained from the top gravel are extremely fine and mostly lost by the methods of mining in vogue. Most of the gold comes from the lowest course, not

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only because of the concentration which would naturally take place on bed rock, but also, I think, because the gold is derived from the very fine quartz and calcite stringers which so thoroughly but irregularly intersect the chloritic schist bed rock. Two varieties of gold are obtained on Causuran Creek, in varying proportions depending upon the location. One is the ordinary rounded and smoothly worn grain, while the other, somewhat lighter in color, is very markedly crystalline and with sharp edges, and frequently contains inclusions of both calcite and quartz. The latter undoubtedly comes from the disintegration of the bed rock and the subsequent crushing of the fine intersecting stringers of calcite and quartz, at or nearly in place.

In four days of mining and one day spent in cleaning up the sluice, a native miner, assisted by his wife and two male helpers, washed approximately 7.5 cubic meters of gravel, cleaning up therefrom 260 grams of gold valued at ₱15.60, equivalent to about ₱2.08 per cubic meter. This was considered as an average run and will give an idea of the richness of the gravel and what might be accomplished if mining were undertaken on a large scale and with such modern hydraulicking methods as are practiced in California.

The smaller tributary creeks contain no water except during the rainy season, but the larger creeks, such as the Causuran, the Bigaa, and the Tagunaan (or Caningan), are fairly large water courses and probably never run absolutely dry. The last two, by the way, showed about as good results in panning as did the first, yet very little mining is done at present except in Causuran Creek.

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NONMETALLIC MINERAL PRODUCTS—STRUCTURAL MATERIAL.

By GEORGE I. ADAMS.

The recent economic development of the Philippines has required the expenditure of large sums of money for the construction of roads and bridges, railways, harbor and river improvements, and public buildings, all of which have created a demand for structural materials. The value of the nonmetallic products used in this way during recent years has far exceeded the combined value of the metallic and miscellaneous nonmetallic products. In this report the first attempt is made to estimate the value of a number of structural materials which have previously been omitted because of the lack of statistics. The returns as reported in reply to official letters of inquiry have been rather meager, but with the coöperation of the larger producers and consumers a fairly satisfactory estimate has been obtained.

STONE.

Under this head the production of cut stone, building stone, marble, crushed stone, gravel, and artificial stone is given.

Cut stone.—The only place in the Islands where cut stone has been reported as being used during the year 1908 is in facing the dam at the headwaters of the Manila water supply. The material is a hard, fine-grained limestone which has been previously employed to a limited extent in Manila and may be found used in part in the General Blanco and Maura bridges, as bases of columns in the Santo Domingo Church, in the sidewalk at the corner of Alix and Alejandro Streets and in the floor of the San Sebastian Church. It has grayish to bluish and yellowish tinges, which uneven coloring renders it unsatisfactory as an ornamental stone, and the presence of fracture lines which develop conspicuously on weathering require very careful selection of blocks for structural use. A small amount of stone was cut during the year 1908. The construction of the waterworks dam is still in progress. In some of the older buildings in Manila cut stone from near the Sisiman quarry (a gray andesite) was used, as for example in the Spanish Bank building. The granite used in stairways and in paving patios and entrances in some of the better older buildings was imported from China.

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Building stone.—In the vicinity of Manila a water-laid volcanic tuff is used extensively as a building stone. Similar material occurs at many other places in the Islands, and this is practically the only stone employed extensively in the Islands. It has a low crushing strength and is not of good quality for structural work, but it is very easily quarried since it can be cut with an ax or bolo, and in the vicinity of Manila can be conveniently transported by rivers and esteros. It is commonly called "dhobe" stone and the trade name of the product near Manila is "Guadalupe stone," taking its name from the barrio of Guadalupe where there are established quarries. "Meycauayan stone" from near the town of Meycauayan, north of Manila, is very similar, although reported to be somewhat better in character. Stone from coralline limestone and coral from coral reefs is used in a small way in many coast towns.

Marble.—The marble found in Romblon Island has previously been used to a limited extent for ornamental and structural purposes. At present the only use of it is in the making of artificial stone, in which small fragments are imbedded in a cement matrix and subsequently polished. The value of the material so employed is insignificant. It is probable that the Romblon marble will come into future use, but before it can compete with foreign marbles it will be necessary to install machinery for cutting and polishing it.

Paving stone.—Under the Spanish régime granite blocks for paving and for sidewalks were imported from China, also basalt paving blocks from Talim Island and a considerable quantity of andesitic paving blocks from near Sisiman were employed in Manila. At present Belgium blocks are being replaced in certain of the streets of Manila by wooden blocks, and experiments are being carried on by the city engineer as to the suitability of cement paving blocks.

Crushed stone.—The city of Manila has a well administered plant on Talim Island for producing crushed stone to be used in macadamizing streets. This quarry produced close to 50,000 cubic meters during the year 1908.

The only large commercial quarry in the Islands is located at Sisiman, near Mariveles, on the north shore of the entrance to Manila Bay. This quarry was opened for the express purpose of obtaining stone for the construction of the Manila breakwater and harbor improvements, but has since continued in operation and during the present year has supplied a large amount of crushed stone for the construction of sewers and other contract work in Manila. Crushed stone was also produced on Corregidor and Grande Islands for use in the construction of fortifications by the United States Army engineers, and at Olongapo for the construction of buildings and wharves by the Navy. By far the largest amount, however, has been used throughout the provinces in the building of roads, bridges, and public buildings under the direction of the Bureau of Public Works, and to a limited extent by the municipalities.

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GRAVEL.

The Manila and Dagupan Railway Company and the Philippine Railway Company have used principally gravel for ballasting their newly constructed lines and for maintenance. In the provinces gravel has been used by the Bureau of Public Works in constructing most of the roads and largely in the maintenance of them, since adequate equipment has not been available for crushing stone, and in many cases the gravel, although not so desirable a material, is decidedly cheaper. Gravel has also been used for concrete work throughout the Islands. In the city of Manila a large amount has been obtained for general construction work by dredges operating in the Pasig River.

SAND.

Sand for concrete work in Manila is usually obtained from the Pasig River by dredging. It is a pebble sand resulting from the decomposition of igneous rocks and contains a large amount of basaltic material. Some sand of poor quality was obtained by dredging in front of the coal pockets at Sangley Point near Cavite. For the construction of fortifications sand was obtained from beaches near the entrance to Manila Bay and Subic Bay. Throughout the provinces sand is obtained locally from the rivers and beaches at the most convenient points.

In general the sands are pebble sands and frequently contain but a small percentage of quartz. The rivers which flow from the Western Cordillera of Luzon (Zambales Cordillera) contain a sand with a large percentage of quartz, and this class of sand at Tarlac came into prominence because of its excellent quality and was at one time recommended as a standard sand for the Philippine Islands. The cost of transportation from this place to Manila or other points where it could be largely used is prohibitive.

In the northwest corner of Manila Bay at the mouth of the Orani River a good sand of the same character as the Tarlac has been found and will probably come into use in Manila for certain purposes where superior sand is required.

LIME.

The most important place in the Islands where limestone is burned for lime is to the northeast of Binangonan, a town on Lake Bay, at which place the industry has long been established. The product is shipped to Manila as slaked lime. The manufacture of lime from limestone is carried on to a smaller extent in other places for local use. On the beach near Manila at Malabon shells are burned for lime, and throughout the Islands shells and coral from the sea beaches are commonly used for this purpose. The amount of lime produced has probably not decreased since the introduction of cement construction, since there has been a large impetus in the building industry. At

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present lime is burned in piles and is partially slaked before it is put upon the market. To supply the market, especially at Manila, it would be desirable to establish lime kilns to furnish unslaked lime. There is an appreciable demand for lime as a disinfectant and to be effective it should be unslaked.

Besides the use of lime as a structural material and disinfectant a small amount is used in the manufacture of sugar and a less important amount is consumed in the chewing of betel nut.

CLAY PRODUCTS.

Brick.—There are a number of brick kilns near Manila which produce soft brick, and throughout the Islands there are many kilns, but the burning of brick is an intermittent industry, and it is very difficult to obtain satisfactory statistics concerning the value of the production. With the introduction of cement construction, brick has fallen into disfavor, because brick walls do not sufficiently resist earthquakes. No vitrified brick is produced in the Islands, but there is at present a demand for it at a reasonable price for paving streets.

Tiling.—Ordinary red roofing tiles are produced to a limited extent near Manila and some tiles for paving floors and areaways. There are, however, two firms which are manufacturing cement roofing tiles and ornamental tiles for paving floors and for wainscoting, sidewalks, and areas. They have largely driven out the use of tiling burned from clay. In addition to the manufacture of tiling, these firms are also making cement sewer pipe, drain pipe, and cable conduit. There are no kilns in the Islands which produce vitrified products. There are undoubtedly suitable materials at some places and there is a promising future for the establishment of this industry.

The city of Manila and some of the principal municipalities have imported a large amount of vitrified sewer pipe.

Pottery.—Ordinary red pottery, such as cooking utensils, water jars, and small dishes, is the only class at present manufactured in the Islands. In addition earthenware receptacles called "pelons," into which crude sugar is poured for cooling in the form of "sugar hats," are required in the manufacture of sugar. Near Manila there are a number of kilns for the burning of water jars and larger earthenware utensils, and throughout the Islands there are a few. The kilns for burning the "pelons" are distributed in the sugar districts, but the making of most of the small pottery is a household industry which is usually carried on by women. The pottery, after being molded and tempered by drying, is piled on the ground and burned under a covering of straw or other light fuel. Certain towns are noted for the production of pottery and in passing through them one hears a constant beating of the pots as they are shaped by hand.

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It is manifestly difficult to obtain statistics concerning an industry carried on in this manner, or even to form an accurate estimate of the value of the production.

Clay.—There are many places in the Islands where clay is obtained for making a sort of cold-water paint or whitewash for painting houses. The natives call this clay *"yeso,"* which might lead one to suppose from the word that it is gypsum. However, no commercial deposits of gypsum are known, and in so far as examined the material more closely approaches kaolin, which has resulted from the decomposition of igneous rocks often aided by the action of hot-water springs and solfateras. Certain of these clay deposits are suitable for the manufacture of pottery and an attempt is being made by the Bureau of Education to establish schools for instruction in the pottery industry. Some clay is used in the making of putty and for calking native boats. From the Province of Laguna a production of 59.5 metric tons is reported, and from Pangasinan a producion of 79.3 metric tons.

CEMENT.

No cement is manufactured in the Philippine Islands. There are, however, several localities where the materials and the necessary fuel can be found, and considerable analytical work has been done by the Bureau of Science in testing samples of limestone, shales, etc., which have been submitted by those who have investigated the feasibility of establishing the industry. Dr. W. D. Smith, chief of the division of mines, has repeatedly called attention to the fact that in the Islands of Cebu and Batan shale, limestone, and coal are found in abundance in close proximity.

The total value of the cement imported into the Islands for the fiscal year 1908 was approximately ₱1,384,202, which indicates a consumption large enough to warrant the establishment of a profitable business.

TABLE I.—*Nonmetallic mineral products, 1908—Structural materials.*[1]

Products.	Value.
Stone	₱149,930
Gravel	171,360
Sand	35,000
Lime	20,000
Clay products	421,628
Total	815,918

[1] The estimates do not include any cost of transportation.

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Families.

a^1. Tail not forked; webs between toes entire or but slighty emarginate.
  b^1. Bill subcylindrical; gular pouch small.
    c^1. Bill strongly hooked..... **Phalacrocoracidæ** (p. 200)
    c^2. Bill sharply pointed.
      d^1. Neck longer than body; bill slender, culmen nearly straight. **Anhingidæ** (p. 202)
      d^2. Neck about one-half as long as body; bill heavy; culmen decurved for terminal fourth ..... **Sulidæ** (p. 203)
  b^2. Bill greatly flattened, widened near tip; gular pouch very large. **Pelecanidæ** (p. 208)
a^2. Tail deeply forked; webs between toes deeply incised..... **Fregatidæ** (p. 206)

Family PHALACROCORACIDÆ.

Bill long and heavy; basal portion of culmen slightly concave, tip strongly decurved and hooked; neck rather long; wings ample but not reaching beyond base of tail, the latter rather long, its feathers graduated and stiff; plumage largely black, at times partly white.

Genus PHALACROCORAX Brisson, 1760.

Characters same as those given for the Family.

166. PHALACROCORAX CARBO (Linnæus).

COMMON CORMORANT.

Pelecanus carbo Linnæus, Syst. Nat. ed. 10 (1758), **1**, 133.
Phalacrocorax carbo Grant, Cat. Birds Brit. Mus. (1898), **26**, 340, text fig. 1; Oates, Cat. Birds' Eggs (1902), **2**, 198; Sharpe, Hand-List (1899), **1**, 232; McGregor and Worcester, Hand-List (1906), 39.

Ca-si-li, Manila, also applied to the dater.

Calayan (*McGregor*); Luzon (*McGregor*); Ticao (*McGregor*). Europe, Africa, northern Asia, Greenland; eastern North America south to Georgia; Indian Peninsula to China and Australia.

Adult in breeding plumage.—Almost entirely black, with a slight oil-green gloss on neck and under parts; chin dirty white, this color continued backward and upward on each side of neck to back of eye, forming

* The *Phæthontidæ* have the nostrils open and the interramal space feathered. No member of this family has been reported from the Philippine Islands.

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With him came two other datus, Muluk and Nukila. But Datu Tating took care to show only part of his numerous followers, concealing the rest in the Island of Banguey, and even in some recesses of Balambangan, which, being covered with wood, as those islands generally are, there was no great fear of discovery.

Surmises, however, had some days begun to spread reports of a plot, while Tating proceeded with such address, that the chief and council, who were not without their suspicious, apprehended no danger very nigh.

During the night strict watch was kept all over the settlement. At dawn, the gun, as usual, announced the morning, and for a few moments tranquillity reigned. A house at some small distance suddenly fired proved the signal to the Sulus. They rushed into the fort, killed the sentries, and turned the guns against the Bugis guard. The few settlers, lately rendered fewer by death, were fain to make their escape in what vessels they could find.[1]

The governor and five others escaped on board a vessel, leaving behind a great quantity of arms and wealth. The English factors who were at Jolo fled in a Chinese junk. In the same year Tating attempted a similar attack on Zamboanga, but failed. During 1776 and 1777 he and other Sulus harassed the Bisayas and ravaged the coast of Cebu.

MORO PIRATES.

Sultan Israel was poisoned in 1778 by his cousin Alimud Din II, the son of Bantilan. During the reign of Sultan Alimud Din II, hostilities between Sulus and Spaniards increased, and for the period of ten years or more traffic between Luzon and the southern islands was paralyzed. About 500 Spanish and native Christians were every year carried into captivity by the Moros. The government was greatly exercised over this grave situation, and in 1789 the Captain-General Mariquina reported to the King that "war with the Moros was an evil without remedy."

In the latter part of 1789 Sharapud Din, the son of Alimud Din I, ascended the throne of Sulu. While a youth he was imprisoned with his father in Zamboanga and accompanied the latter to Manila. Very little is known of his reign except that he was animated by the same spirit and principles which characterized his father's reign and that of his brother Israel. He coined money, and one of his coins which was obtained from Jolo bears the date 1204 A. H., which was probably the date of his succession. Sultan Sharapud Din was followed by his sons Alimud Din III and Aliyud Din I.

The continued presence of the Moros in Mindoro, where they haunted the bays and rivers of both east and west coasts for months at a time, stealing out from this island for attack in every direction, was specially noted by Padre Zuñiga,

[1] A Voyage to New Guinea, Capt. Thomas Forrest, pp. 336–337.

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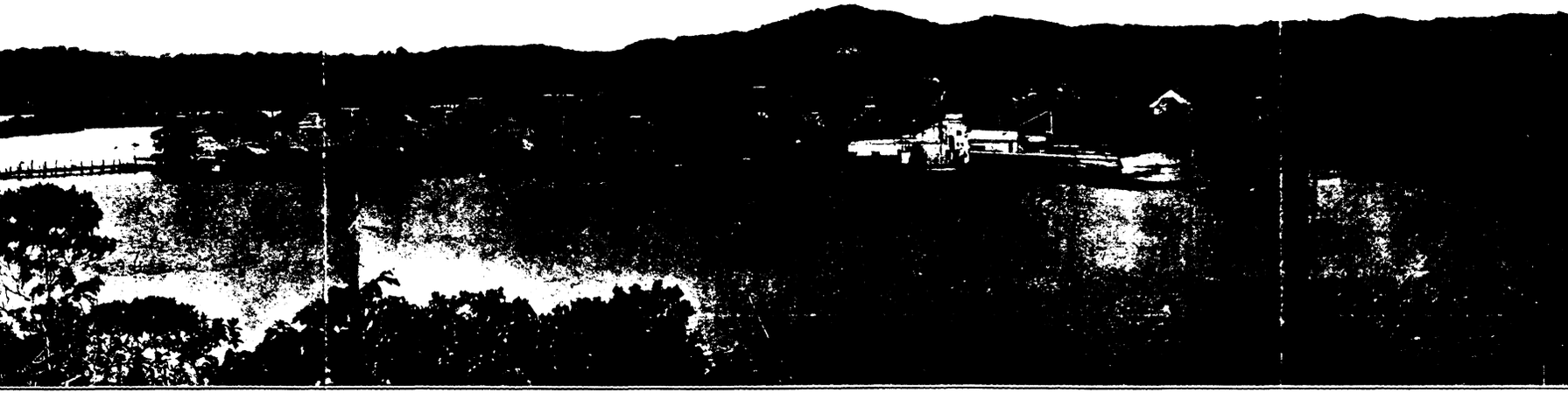

PLATE I. PANORAMA OF PAHACALE.

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ERRATA.

Page 11, line 1, for "**a part**" insert "**besides that.**"
Page 12, line 34, **70-horsepower** instead of **7-horsepower.**
Page 22, line 12, read **₱10** instead of **₱5.**
Page 27, line 7, read **invariably** for **unvariably.**
Page 37, line 22, read **lower** for **longer.**

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THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS

WITH A STATEMENT OF THE PRODUCTION OF COMMERCIAL MINERAL PRODUCTS DURING THE YEAR 1909

ISSUED BY

THE DIVISION OF GEOLOGY AND MINES,
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STATISTICS OF PRODUCTION.

TABLE I.—*Mineral production in 1909.*

[In pesos [a] Philippine currency.]

Source.	Gold.	Silver. [b]	Copper.	Iron.	Manganese.	Coal.
Albay						[c] 197,184
Ambos Camarines	216,701					
Bulacan				31,078		
Ilocos Sur	1,425					
Ilocos Norte					12,500	
Masbate	[d]					
Mindanao (Surigao)	10,608					
Mountain Province	256,400		[e]			
Nueva Ecija	7,200					
Pangasinan	2,500					
Tayabas	360					
Total	495,194			31,078	12,500	197,184

Total metallic with coal	735,956
Total nonmetallic	1,504,091
Grand total	2,240,047

TABLE II.—*Comparative statement of mineral production in 1907, 1908, and 1909.*

[In pesos Philippine currency.]

Year.	Gold.	Silver.	Copper.	Iron.	Coal.	Manganese.	Nonmetallic.
1907	141,194	95.53			26,799		
1908	134,500	2,750.00	52	17,500	77,166		815,918
1909	495,194	[f]		31,078	197,184	12,500	1,504,091

[a] One peso Philippine currency is equal to fifty cents United States currency.
[b] Some silver generally found alloyed with Philippine gold. None is mined separately.
[c] 30,336 tons, at 6.50 pesos per ton.
[d] No mills running.
[e] Small amount smelted by Igorots.
[f] Not estimated separately.

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INTRODUCTION.

The production of gold in 1909 shows only a slight increase over the preceding year. A careful investigation of the facts demonstrates that this is not an unhealthy sign. The chief cause of the apparent setback in Benguet was due to severe floods which for a time crippled the two largest plants. However, another reason is found in the fact that the operators of mines have reached the conclusion that a larger amount of work than formerly should be expended on development, rather than as at present in operating mills. An encouraging amount of underground work is now being done on the majority of the properties, and in some cases some very large bodies of ore are blocked out. Those who have waited the longest before putting up mills have not only the advantage of large blocks of ore, but also can utilize the experience of others who have operated.

The increase in the coal output is very satisfactory, as is also the awakened interest in other deposits such as oil, sulphur, and iron. Copper, too, is receiving close attention. Perhaps the greatest interest of the year has been in the Tayabas oil fields. Many claims have been located on the peninsula. Recently an oil rig was shipped to the region, and it is hoped that encouraging results will soon be obtained.

The Bureau of Science wishes to express its thanks to all who have coöperated with it in making the publication of this bulletin possible.

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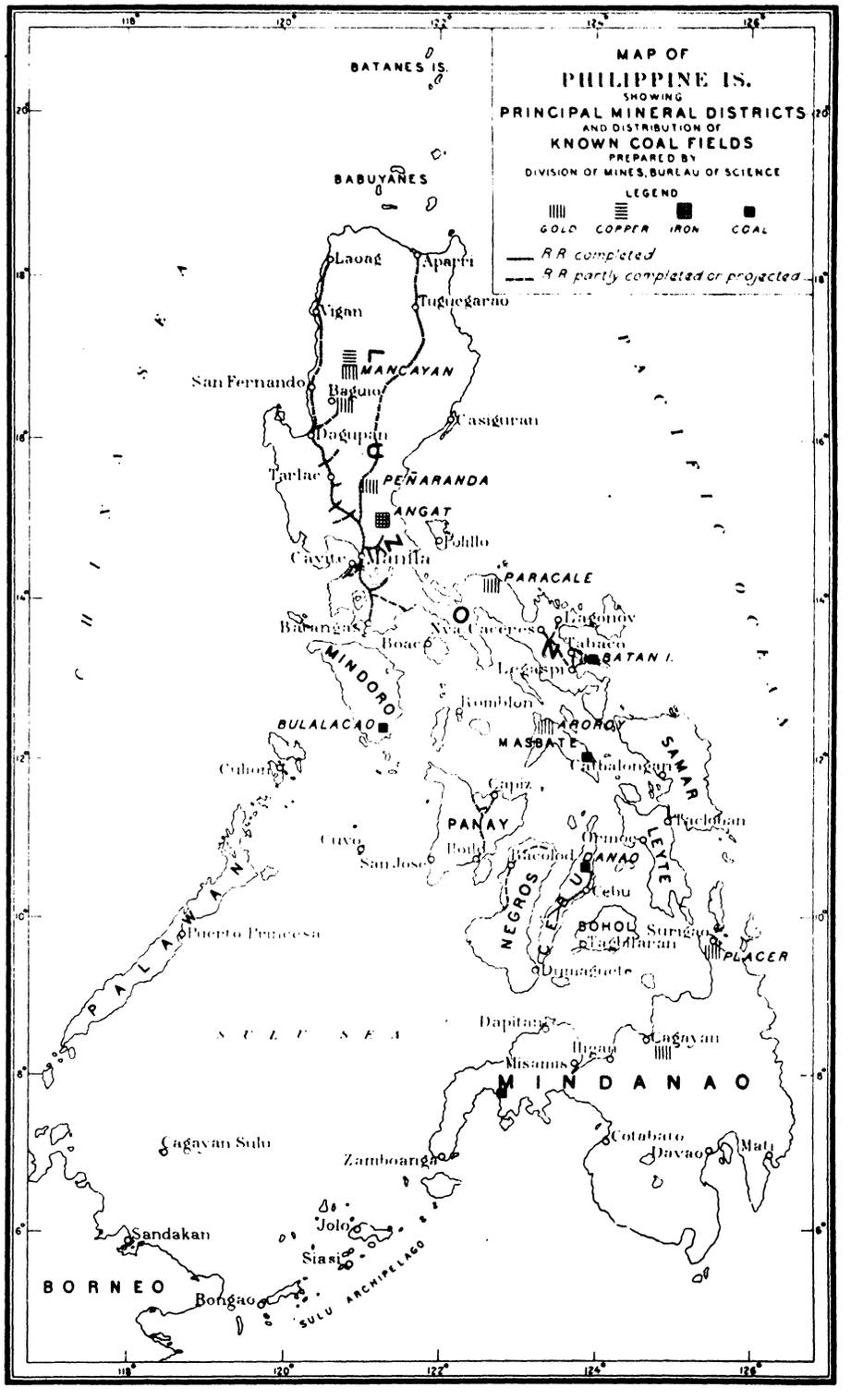

PLATE II. OUTLINE MAP SHOWING MINERAL DISTRICTS.

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THE GOLD DISTRICT OF PARACALE-MAMBULAO, AMBOS CAMARINES.

By WARREN D. SMITH.

The Paracale-Mambulao gold field has for centuries been known to the natives as rich in gold, and it was exploited in a crude way by the Spaniards by means of arrastres.

The first mention of this district of which we have an authentic record was in 1571. The Chinese and natives worked the rich streaks and alluvial ground for many years in a crude way, until Spaniards from Mexico taught them to use the arrastre, and a few years before the American occupation nearly a score of these crude appliances were in use in the hills of this district, and small but fairly effective dipper dredges, which could only handle a few cubic meters a day, had been set in operation.

A large corporation known as the Philippine Mineral Syndicate just before the insurrection had acquired extensive concessions from the Spanish Crown. Operations of modern character were first undertaken on the Tumbaga property.

This district roughly comprises 400 square kilometers of country of moderate relief. The topography is marked by a number of hills which extend outward as spurs from the cordillera and have approximately a north and south trend. Between these hills are broad valleys to a great extent filled with nipa and mangrove swamps. The whole country is densely wooded. The most elevated point in the district is Mount Bonotan, some 500 meters in height.

Metamorphic rocks are a prominent feature of this area. The formations to be found are pyroxenite, schist, granite-gneiss, shale, sandstone and andesite from north to south in the order named. The strike of the sedimentaries is roughly north and south and they now stand nearly on end.

Prior to the Miocene disturbance, which flexed these formations into a more or less vertical position, the section of the strata was probably as follows: At the base a pyroxenite and diorite complex; above this sandstone, shales and possibly limestone, with andesite overlying. With the Miocene uplift came the intrusion of granite, and exposures of the granite cutting across the basic rock can be seen. Along the contact of the two, gneiss and schist were developed. Later on, and probably before the outflow of andesite, there began a period of vein filling and

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ore deposition. Naturally, the principal deposition took place along the weak zone of the contact and in the fractures adjacent to it. The principal lodes to-day are found normal to this granite-diorite contact. There are many parallel veins running through this granite batholith. The placer deposits are found along the rivers which cut across these veins and are naturally richer near them.

PRESENT OPERATIONS.

There was only one dredge in operation in this district at the time the last annual bulletin was published, and all the lodes remained practically as the natives and the former Spanish and English operators (the Philippine Mineral Syndicate) had left them.

MAMBULAO.

A year ago only the ancient workings and those of the syndicate existed in this part of the district, together with a few recent shafts and tunnels driven as assessment work. Since that time two companies, the Tumbaga and San Mauricio, have been preparing for immediate operation.

Tumbaga.—Tumbaga lies some 2½ kilometers south of the town of Mambulao. The ore body is in a brecciated zone between andesite (porphyry) and impure sandstone, or tuff. The trend of the ore body is northeast-southwest. In this there is considerable slate through which innumerable calcite stringers ramify. Some of these stringers have been found to carry free gold; possibly all of the values may be found to lie in these innumerable veinlets cutting the slate. Although the mineralized zone in places reaches a width of 35 feet, this is not constant. The ore body is lenticular.

Mr. Cavender, the superintendent, has opened up over 100 meters of drifts and crosscuts, most of which is new work, also a shaft over 15 meters deep, and has constructed a drainage tunnel of over 100 meters. He has also, assisted by Mr. Collins, put into working order the old plant of the syndicate, parts of which were missing and the remainder in considerable disorder, so that he was able to make a test run on his ore. The plant as it now stands consists of the following parts: a Blake crusher; a 5-feet Huntington mill, having a capacity of from 12 to 30 tons per day; two Johnson concentrators; besides the usual accessories—boilers, hoisting drums, skips, etc. According to Superintendent Cavender, a trial run of twenty-two hours was made with this plant in November last. Eleven tons of ore were treated, with the result that 93.6 ounces were cleaned up, which represented merely the free milling part of the ore. The concentrates have not been treated. If these figures are correct, and I have no reason to doubt them, this ore contains some very rich streaks, and there may be found to exist a considerable ore body besides of low grade material.

San Mauricio.—This property is located 1 kilometer from Mambulao on the hill to the north of the town. The ore body is in part a quartz filling normal to the contact between the granite and the basal rock, which here is more nearly a diorite than a pyroxenite. There also appears to be some ore deposition along the contact.

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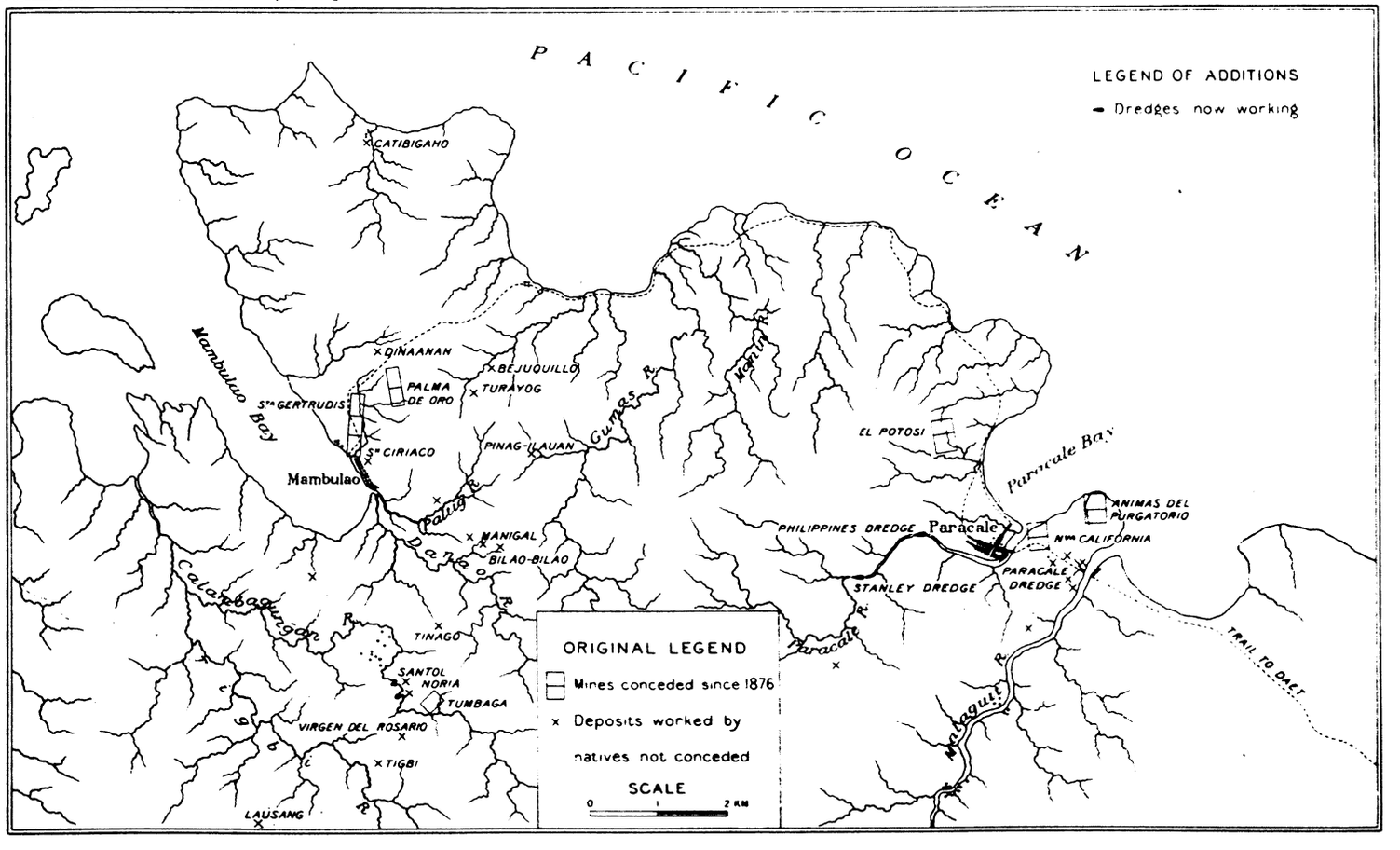

PLATE III. OUTLINE MAP OF PARACALE-MAMBULAO DISTRICT.

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About 300 feet of drifts and crosscuts have been opened up, a part representing old workings, and extensions made by the present company. Besides this development work, a 20-stamp Traylor mill consisting of the following parts has been erected: 20 Traylor stamps, Blake crushers, Challenge feeders, and 8 Traylor concentrators and a Richard's classifier. The stamps are 1,050 pounds each and it is proposed to have them dropped at the rate of 94 times a minute through a 5-inch drop. This mill, for completeness, general plan, and the way it has been set up, should be a model for future mills in these Islands. In October of this year, a severe typhoon raged on this coast and did more or less damage to all the properties. At the San Mauricio the head frame was blown down, but no other serious damage was done.

Other lode properties on which development work has been carried on are as follows:

Dinaanan, north of San Mauricio; the Le Duc property, southwest of Mambulao; and the group of claims known as the Iron King, Gordon, Isla, Guinto, Abe Lincoln, and Navotas, a different property, all a short distance east of Tumbaga. These are all promising prospects.

PARACALE.

The present operations in this district are confined almost entirely to placers.

Since our last report, two more dredges have begun operations on the Paracale River above the Paracale dredge. The Stanley dredge, farthest up the river, is a New Zealand model, operated by New Zealanders. The Philippines dredge is a Risdon make and was operated by an American company. The hull for the fourth dredge is almost completed and plans for the fifth are under way. Of the three, the two New Zealand dredges are running steadily, but I regret to say that the third, up to the present time, has failed to secure results and has temporarily shut down. The Paracale Extension is a new company which proposes to work ground farther up the Paracale River above the Stanley.[1]

Most of the ground on the Paracale and Malaguit Rivers has been tested and staked. However, as yet no operations have been undertaken on the latter. These rivers lie in broad valleys, covered with mangrove and nipa, through which the dredges work their way. The mangrove is used for the firewood and the nipa is either thrown aside or employed by the natives for house building.

A test hole in an adjacent river, which serves to give a general idea of the ground to be dredged, showed the following strata:

From 0 to 1.5 meters, soil, nipa, etc.

From 1.5 to 7.6 meters, sand and gravel, with some values.

From 7.6 to 11.5 meters, heavy black loam, with considerable decayed vegetable matter.

From 11.5 to 12.2 meters, gravel, pay streak.

The bed rock is a white, soft, decomposed granite-gneiss.

In some of the localities the bed rock varies in depth from 3 to 18 meters. In the last few months testing parties have been very active; one working along

[1] As this Bulletin goes to press it is learned that the Philippines dredge is being moved to the Malaguit River.

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the following rivers: Tabas, Malaguit, Malagbang, Bosignon, Gumaus, Bulalakao, Colombayungon, Tigbi, Maniloc, and Ponso; others have carried on extensive boring in the Malaguit River, one company having put down over 300 holes, and this is only a small proportion of the total. The Paracale River, of course, has been the most thoroughly tested of all the field, but others, especially the Gumaus, have shown up well in the tests.

The ground being worked by the dredges now in operation is unusually rich, yielding ₱2 per yard,[1] according to the dredge master's sworn statement, and there are several spots where values as high as ₱14 per cubic yard have been reported. It is not likely that such values will be found in all parts of the district, the richness of certain spots being due to the fact that the river cuts across the veins in these places. This can easily and clearly be seen by an examination of the field relations and of the fresh, crystallized gold as it comes up on the dredge. There is not much doubt but that there is much profitable ground and the district can support several more dredges.

Many may not be familiar with New Zealand dredging practice, so that a few of its essential features, as I have observed them in this district, are here given.

Both the Paracale and Stanley dredges use the open-connected buckets and have no stacking ladder, but differ entirely in the gold-saving appliances.

The Paracale dredge has a revolving screen, side tables and table sluices, expanded metal and coco matting being used.

The Stanley has no revolving screen and no side tables. It has two sluices copied from pattern of the old tail sluices, one being placed above the other. The dimensions of the first are 75 feet by 4.5 feet, those of the second 65 feet by 3 feet and 8 inches, with a fall of 1.5 inches to the foot. The riffles in the two sluices are about the same, and, beginning at the top, are as follows:

First Hungarian riffles; then California riffles with a few T-shaped riffles; next undercurrent riffles for the fine gold with coco matting beneath; and finally plates with three-eighths-inch holes with 1.5-inch pitch with coco matting and expanded metal under all riffles. A 12-inch pump supplies water for the upper and a 10-inch for the lower one.

An 8-ton, semi-marine boiler provides the steam for a 7-horsepower Marshall engine, which runs the buckets and the 12-inch pump.

The essential differences between the New Zealand and the American (Risdon) dredge on the river are:

(1) Absence of the stacking ladder.

(2) Absence of a screen and side tables, in the Stanley dredge.

The dredges have not been working under similar conditions, and hence it is at present impossible to make any comparison regarding the relative efficiency of the two systems. The persons in charge are well aware that changes will need to be instituted to adapt the process of dredging to the ground. Mr. Jones stated that some of the values are being lost, particularly the fine float gold and that which adheres to the black sand.

[1] ₱ is the symbol for the Philippine peso.

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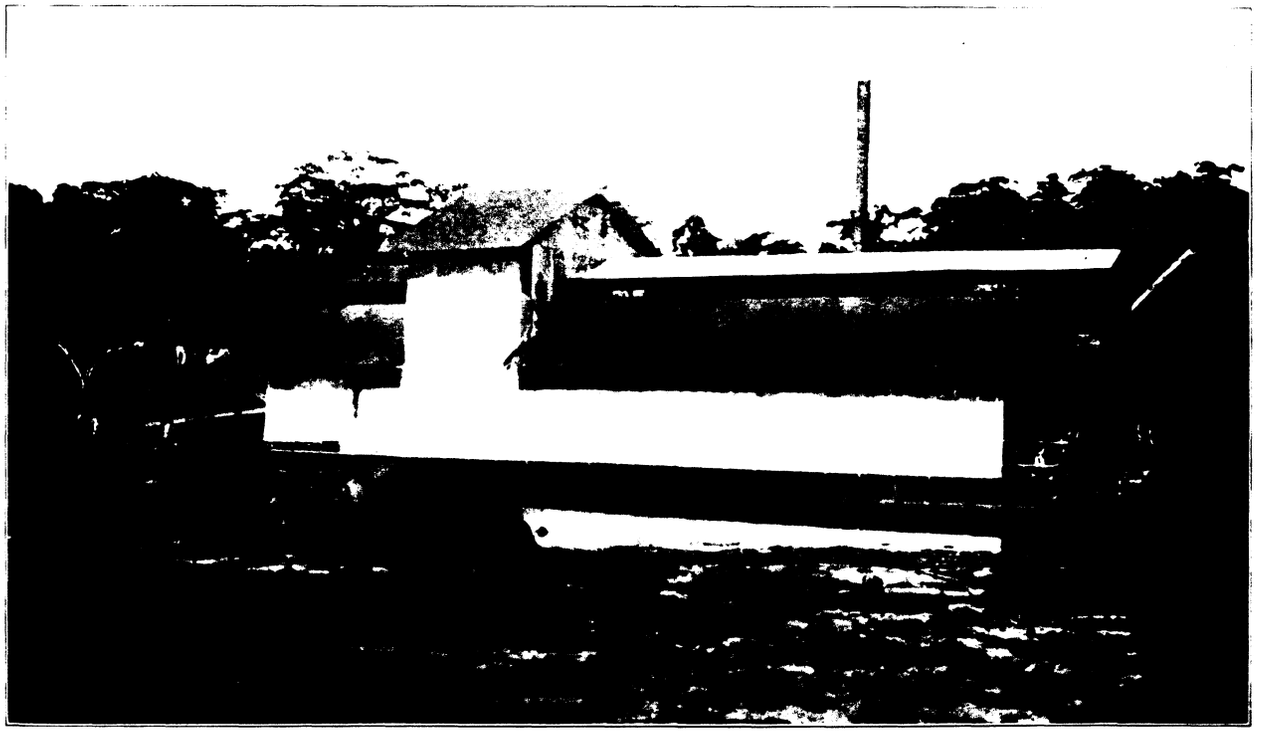

PLATE IV. STANLEY DREDGE.

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The cost of operation per yard is still high, being close to 30 centavos, but the new dredges will embody several improvements as a result of the past experience with the ground, and a diminution may be looked for. One noteworthy feature at present is the difficulty experienced in amalgamating the gold secured by these dredges. The Paracale Company is installing a Huntington mill to treat the large, rich, quartz bowlders which are constantly being encountered.

LODE PROPERTIES.

Lode properties are not receiving as much attention in the vicinity of Paracale as near Mambulao; nevertheless development work is being carried on the Germania claim in the foothills north of the Paracale River and on the San Antonio and Empire groups on the peninsula between Paracale and Malaguit.

Even a casual examination of some of the veins on this peninsula gives rise to the hope that a producing mine will before long be located here.

Just at present the labor conditions in Paracale are not entirely satisfactory. The Camarines coast is but sparsely settled and but little opened up by commerce, but the conditions should improve.

At Nalesvetan in the cordillera south of Paracale some new prospects are located and are being vigorously developed by a party of Americans. They have reported some fairly rich strikes from there in the last few months.

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THE BAGUIO MINERAL DISTRICT.

By FRANK T. EDDINGFIELD.

American miners have been prospecting in Benguet for ten years or more, but only during the last three years has successful mining been carried on by organized companies; previous to that time the veins had been worked by Igorots, Filipinos from other provinces, and Chinamen. Some of these old workings are quite extensive, and have been a great help to the prospectors of to-day in locating the veins. They are similar to the workings found in other parts of the Islands, where only the rich stringers were gouged out, and are consequently so narrow that an American would find it almost impossible to go through them.

One of the drifts in Mr. Kelley's mine cut an old stope filled with waste that had cemented as hard as the wall rock.

The mineral statistics show production of gold from the district to have been ₱155,520 in 1907, ₱279,600 in 1908, and ₱243,500 in 1909.

The figures given for 1909 are estimated from partial data, for nine months' work. The production was stopped in October by floods. The same rate of production would have given about ₱320,000 for twelve months.

These figures to a certain extent show the advance of mining in Benguet, but they give no idea of the great amount of work that has been going on in development. It is estimated that about 300 claims have been located and almost 250 veins uncovered. One company alone claims to have found 132 veins on a group of 31 claims.

The known mineralized district extends from the headwaters of the Antamok on the north to the headwaters of the Batwaan on the south and from Camp John Hay and the Bued River on the west for a distance of 10 kilometers to the eastward, thus comprising an area of about 75 square kilometers. Outside of this area there is much which is believed to be valuable ground, but as yet unexplored.

The majority of the veins appear to be true fissure veins in andesite. However, this point is open to further investigation. Toward the south and west contact deposits are reported between andesite and diorite, and andesite and limestone. The veins have a general strike of east and west and a dip of about 60°, usually to the south. They vary in width

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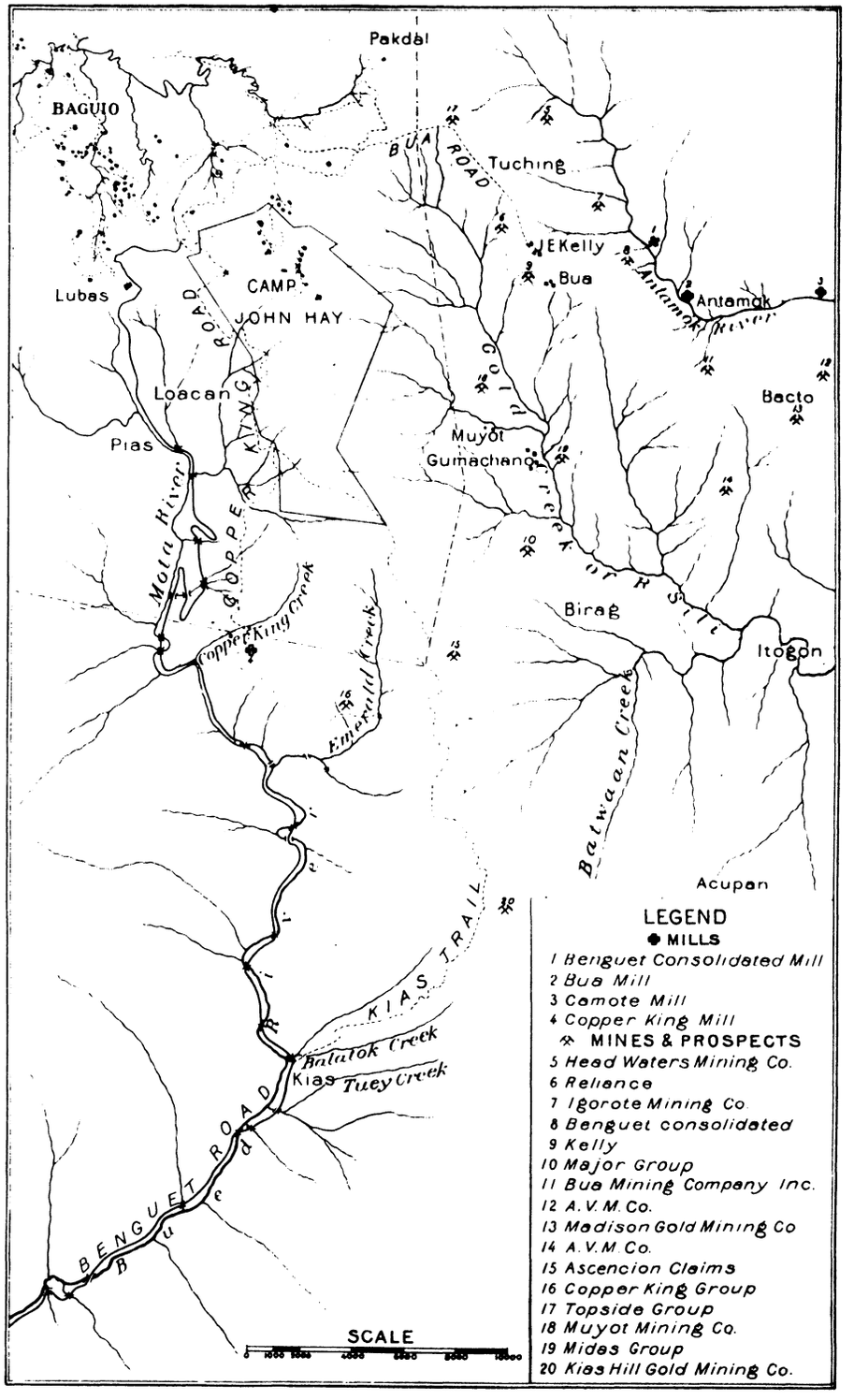

PLATE V. OF MAP BAGUIO MINERAL DISTRICT.

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from 0.3 to 6 meters, reaching a maximum of 15 meters in one case. The classes of vein matter are white quartz, crystallized banded quartz, calcite, calcite and rhodochrosite, brown manganese and quartz, mineralized dikes, and brecciated material. The gold content is about 50 per cent "free milling" in most of the veins, but some of them do not pan a color, as in the case of the telluride ore on the property of Mr. Kelly.

At the present time there are good wagon roads leading to the Headwaters, Consolidated, Bua and Major mines which can also be used by properties near by. The other groups can only be reached by horse trails.

The majority of the properties are so situated that water power can be utilized, but a few will have sufficient water only during the rainy season. The grades are steep so that "gravity mills" can be built, saving expense in handling the ore, and making it possible to have high heads of water with a comparatively short pipe line and flume. The only serious disadvantages are the dangers of floods or landslides, the difficulties of transportation, and the comparative scarcity of timber.

The labor situation is perhaps better than in any other mining district. Igorots are easily obtainable for surface labor, road building, packing, and cutting timber; Filipinos from other provinces for miners and mill men, and Japanese for timbermen and carpenters.

The average prices, in Philippine pesos, are:

Common labor	per day	₱0.70–₱1.00
Miners	do	1.30– 1.70
Native capatas	do	1.70– 2.50
Japanese timbermen	do	1.70– 2.50
Japanese carpenters	do	3.00– 3.50
By contracts:		
Prospect pits	per meter	3.00
Drifting	do	15.00
Timber:		
Posts 7 feet by 1 foot	each	0.70
Logging 2 to 3 inches by 12 feet	do	0.10
Sawed lumber	per M feet for labor	45.00
Mining and milling	per ton	5.00– 8.00

Filipinos from other provinces are preferred to the Igorots for miners and millmen. They give steadier labor and are better workmen. Japanese are used as timbermen in some mines because of their greater strength and adaptability.

The companies now existing are the Antamok Valley Mining Company, Madison Gold Mining Company, Bua Mining Company, Benguet Consolidated Mining Company, Igorot Mining Company, Muyot Mining Company, Major Mines Company, Copper King Mining Company, Camote-Clayton Company, and Kias Hill Gold Mining Company. In addition, the prominent groups of claims are: the Ebert, Topside, Vicente Volpiedad, Lorenzo Pau, McElroy, Calvin Horr, Murphy, Missionary, and McDill.

The only companies at present producing are the Benguet Consolidated and the Bua.

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The Bua is working two veins at Gomok, one a quartz vein 0.3 to 1 meter wide, the other a rhodochrosite vein 1 to 2 meters wide, striking north 10° east and dipping 65° to the south. The veins have been opened up by drifts for a length of 166 meters and have been cut 33 meters below by a tunnel 200 meters long.

The ore is mined by the system of overhead stoping, filling with waste broken during mining. The stope extends the entire 166 meters, and has ore chutes every 10 meters. The ore is dumped into a bin near the mouth of the adit, from which it is trammed for a distance of about 1 kilometer to a second bin, which feeds into a two-bucket gravity aërial tramway, stretching across the Antamok Valley to the mill. The mill is run by a water wheel with a rope drive. It consists of six individual stamps in groups of three, with two copper plates. The tailings are cyanided in six sand leaching tanks, and then dumped into the river. The average value of the ore is said to be ₱14 per ton.

The Consolidated sustained severe losses in the cyanide plant during the typhoon in the preceding autumn and in consequence has reduced its output until the plant can be refitted. The mine had been working a good strong lead which is said to assay from ₱30 to ₱200 per ton. The lead was opened up on four levels 16 to 26 meters apart, the lower levels being reached by a small inclined shaft with a skip and an underground station.

The usual feed of the mill was 20 to 25 tons per day. The ore was fed to a crusher, then to stamps and amalgamation plates. The tailings were classified and leached by a sand and slime leaching plant. The leached slimes were filtered in a Ridgway vacuum filter. The introduction of a vacuum filter was a pioneer step in the Philippines and will undoubtedly lead to greater activity along the same line.

The Camote is one of the largest ore deposits in the district. The vein is manganese and calcite and is said to average 8 meters in width. A large amount of ore has been developed and 500 meters of working have been driven. It is said to "catch ₱13 on the plates alone." The company lost a 3-stamp mill in the landslide last fall, but they will undoubtedly erect another mill in the near future.

The Headwaters have put in 1,000 meters of drifts and tunnels, showing four veins which run generally east and west, and dip 45.° They are working 44 men in the mine, 21 on road construction, and are preparing to install a 10-stamp mill, 1,000-pound stamps, tube mills, cyanide plant and a filter press.

The "Muyot" has 800 meters of drifts, tunnels and raises in a vein 2 to 10 meters wide said to average ₱12. It is most admirably developed and shows a larger tonnage of "ore in sight" than any mine in the district.

The Madison has about 330 meters of work on two veins which are claimed to be the same as the Bua.

The Topside has 166 meters of work on two veins.

The Copper King has 666 meters of work on four veins, varying from 0.3 to 3 meters. This ore contains lead, copper, and considerable free gold.

The Kelley group on the north slope has four veins: No. 2, north 60° west, dipping 60° to north; No. 3, south 60° west; and No. 4, north 34° west. If these directions maintain, they will all intersect. The intersection of 3 and 4 has already been opened up. The outcrops of these veins are well marked. No. 1, particularly, shows as a strong, high dike on the bank of a stream. One thousand meters of drifting has been done on the veins which vary from 1 to 3 meters and are said to run ₱24 to the ton. They carry no free gold, but are rich in tellurides. On the south slope Mr. Kelley has cut four more veins with 500 meters

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of workings. These veins run generally east and west and vary from 0.6 to 10 meters in width. About half of the gold in this group is free milling.

The Major Mines Company has discovered a large number of veins on their property. The No. 3 vein on the Low Potential claim is most unusual. It is made up of bands of crystallized brittle quartz separated by horses of andesite, and having a width of 1 to 3 meters. The majority of the veins on this property pan very high. When in full operation this company should be one of the largest producers in the Islands.

The Antamok Valley Mining Company has perhaps the largest holdings in Benguet. They have made a large number of tunnels and cut some very promising veins.

Lorenzo Pau is working 12 claims; Vicente Volpiedad, 6 claims with two or three good leads. Calvin Horr has done a great deal of work proving up several good leads, one of which is 3 meters wide, and is said to carry ₱16. The Camote-Clayton, McElroy, McDill and the other properties all have more or less work done. Some mills are already being erected in the southern part of the district.

The great number of veins, their uniform directions and dip are significant facts. A peculiarity of the district is that the veins often occur in groups of four.

The great need of the district is a large mill adapted to the character of the ore, then mining can be done on a sufficiently large scale to make it economical, and there will be enough tonnage in the mill to reduce the cost of treatment. An output doubled means a gain of almost 80 per cent in clear profit. Furthermore, a mine taking out and milling 150 tons a day economically would do much toward bringing in the right kind of capital to the Islands.

As yet the mineral deposits of the Philippine Islands have only been scratched, and only ore close to the surface taken out. If these districts were found with as favorable locations in the United States, there would not be the slightest delay in establishing an exceedingly active camp in every one of them.

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THE AROROY MINING DISTRICT.

By H. G. Ferguson.

The Aroroy mining district lies in the northwest part of the Island of Masbate at the junction of the two anticlinal prongs which make the island. On the western side of the district Port Barrera, an excellent harbor, extends inland for 12 kilometers in a southwesterly direction. Ticao Strait is to the north and the highest part of the island lies on the south and east, reaching its greatest elevation in Baha Simbahan (630 meters) 15 kilometers to the eastward. The topography in the district itself may be described as semimountainous.

A great number of small hills and ridges lie near the bay, generally trending in a northeasterly direction. Three large hills occupy the central portion of the area. The northernmost of these, Mount Aroroy, has an elevation of 250 meters and is separated from its southern neighbor, Mount Bagadilla, by Bangon Creek, a tributary of the Guinobatan. Mount Bagadilla has an elevation of about 340 meters and is separated from Mount Kalakbao (elevation of 202 meters) by the deep cañon of the Guinobatan River. These three hills all trend to the northwest and owe their height to the greater resistance offered to erosion by the numerous quartz veins which outcrop here.

Another prominent hill is Mount Cogran, a ridge running northwesterly in the southern part of the district, along which the vein worked by the Tengo Mining Company outcrops.

The country is covered with cogon; but a thick forest containing valuable timber is found a few kilometers inland. Mangrove swamps, which will furnish excellent firewood grow at the mouth of the Guinobatan and Lanang Rivers.

GEOLOGY.

The oldest rocks outcropping in the district are of sedimentary origin, chiefly red slate with subordinate amounts of black slate, feldspathic sandstone and conglomerate. The sedimentary area covers a large part of the country north of Mount Aroroy and extends southward to the east of Mounts Bagadilla and Kalakbao and up the valley of Kaal Creek to

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PLATE VI. RELIEF MAP OF AROROY DISTRICT.

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the west of Mount Villon. The hills north of Mount Aroroy are in part composed of quartz diorite, which is an intrusion into sediments just mentioned.

However, the greater part of the district is covered by an extensive series of later volcanic rocks which are principally augite and hornblende andesites, the former preponderating, with occasional more basic rocks. Mounts Aroroy and Bagadilla are composed of andesite flows and agglomerates, while the region lying between Panique Creek and the Lanang Hills is almost entirely composed of pyroclastic rocks. The hills lying between these two areas and Mount Villon consist of andesites and may represent the stocks of the volcanic vents from which the flows and agglomerates covering the greater part of the district have issued.

As is common in mining districts, the period of volcanic activity was followed by the stage of vein formation. The parallelism of the fissures with the long anticlinal axis of the island makes it probable that they were contemporaneous with this folding. Thus, following the general history of the Islands, the veins may be considered to date from early Tertiary times.

On the western side of Port Barrera, the formation is that of coastal plain composed of more recent sediments. Near the west shore of the bay in several places a gray shale of Miocene age outcrops, similar to that found above the coal measures of Batan Island. This shale was recently prospected for coal, but the drill encountered nothing but shale for a depth of 40 meters below sea level. Above the shale is a conglomerate containing pebbles of andesite and vein quartz, proving that these sediments are derived from the formations found across the bay. The drainage of the Aroroy district suggests that the streams overflowed over this series of sediments which then covered the district. Several beds of limestone which dip slightly to the west and northwest lie above the conglomerate. On the north coast and at Punta Colorada are flat lying coral limestones of more recent date.

ECONOMIC GEOLOGY.

The principal veins upon which development work has been done are confined to the comparatively small part of the area included in the three hills of Aroroy, Bagadilla, and Kalakbao, forming a rectangle about 5 kilometers from north to south and 2.5 kilometers from east to west.

The claims lying in this area are the Keystone Mining Company on Aroroy Mountain, the Colorado and Cripple Creek Mining Companies on Bagadilla, and the Syndicate and Aroroy Mining Companies on Kalakbao. Outside lie a group of claims east of Bayuan Bay, the claims of Mr. Hayes to the east of Mount Villon, and the property of the Tengo Mining Company in the southern part of the district.

The veins are often from 2 to over 6 meters in width, and usually quite regular; movement parallel to the vein as a rule is shown on both walls and often in the vein itself. This is almost universally true along the foot wall. The dips are steep, varying from 50° to vertical.

The veins on the north side of the Guinobatan dip to the northeast, those on Mount Kalakbao to the southwest. In general, the strikes are northwest, but on Mount Kalakbao two cross veins cut off the El Sol series and the large Mabel vein on the Syndicate property. Transverse faults are rare, the two veins just mentioned being the most prominent. In the Nebraska Star mine the main

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vein is displaced about 5 meters by a vertical fault striking east and west. In the Nancy workings on Kalakbao there is evidence that slipping parallel to the side of the hill has displaced the veins somewhat, but development work has not as yet progressed far enough to show how important this feature is.

The strong relief of the district brings a large portion of the country above the ground-water level, and this feature, together with the long continued elevation, has given a deep zone of oxidation; operations on Aroroy, Kalakbao, and Bagadilla Hills to a depth of nearly a hundred meters from the surface showing oxidized ore. Work nearer the water level, as on the Montana vein, shows partly altered sulphide ore. The unaltered form of the ore seems to be a hard, massive bluish quartz containing pyrite.

However, practically all the development work has been done in the oxidized zone, and this will be of the greatest importance in the immediate future. Here the ore is entirely different in appearance. Shearing and slipping in the veins, the effects of which are concealed in the sulphide zone, have caused the segregation of the different minerals into bands.

This banding is more marked near the walls, especially the foot wall where movements have been more common. Characteristic oxidized ore may be seen on the main vein of the Colorado mine and near the foot wall of vein number 2 of the Nancy. Here the ore shows regular black and white stripes of alternate manganese oxide and white quartz varying in thickness from a mere pencil line of manganese to bands of quartz a meter or more wide; and often considerable gouge is present. The black bands seldom consist of pure manganese oxide, but are usually composed of small quartz fragments coated with black, sooty powder. The larger quartz bands, while white or stained with iron oxide near their edges, frequently show a core of unaltered blue quartz. Bands of iron oxide are often present, but are not as common as the black and white banding. Bands of white calcite occur, although near the surface this mineral is rare, as there the calcite has been dissolved by surface waters, leaving a skeleton of quartz ribbons. Regular banding is rare in the center of the veins and the ore commonly takes the form of a much-broken quartz stained with iron or manganese, often honeycombed throughout with spots and patches of manganese or iron oxide, in other places massive and iron stained, the larger fragments having blue cores. So far it is not clear whether the best values follow any particular phase of this banding, and it can only be said that the higher grade ore (assaying above 10 or 15 grams to the metric ton) occurs in rather irregular masses and pay streaks, with a tendency to follow the foot wall.

The country rock, generally an andesite or agglomerate for varying distances from the walls of the vein in the oxidized zone, is altered to a brown clay-like rock which locally bears the name of "porphyry." This "porphyry" often contains numbers of small quartz veins, varying from minute stringers up to those half a meter in width and it sometimes carries workable values for several meters from the walls of the vein. In all probability the value occurs in veinlets, rather than as an impregnation of the country rock itself. A mass of what appears to be a much decomposed sandstone cut by several small veins occurs on the Gold Bug claim. The sandstone shows excellent values to the limit of oxidation, which in all probability are the result of impregnation supplemented by surface concentration.

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The area of sedimentary rocks lying east of Mount Bagadilla and extending southward down the valley of the Kaal, consists largely of red slate containing deposits of psilomelane. As yet, not enough work has been done to ascertain if these are of any value, or to determine the size and origin of the deposits. In all probability they occur as a series of lenses, some of which may be of workable size. Pebbles of specular hematite are found in the small stream north of Mount Aroroy, but the outcrop has never been discovered.

MINING.

In all probability mining was carried on before the Spanish conquest.

Old, open cuts, the rounded edges of which show the use of fire in breaking the rock, are to be found on many of the veins. Also in several places numbers of stone mortars used for crushing the ore have been found. I have been unable to find any record of Spanish workings in the district, although the natives say that about a hundred years ago an arrastra, the ruins of which are still to be seen, was worked by a Spaniard and an Englishman; and in several places, as, for example, on the Buena Suerte and Montana claims, there are underground workings that can not date very far back. The only reference to mining before the American occupation which I have found is in a description by Gemelli[1] of his voyage around the world.

Prospecting in Masbate began soon after the arrival of the American troops, and American work in Aroroy may be said to date from the year 1901.

The conditions are favorable for cheap mining in this district. The topography of the country allows considerable exploration to be done by adits and the ore is easily treated. The labor supply is at present in a fairly satisfactory condition. Good timber is available on the majority of the claims and fuel may be had at moderate cost. The most important mines are situated less than 3 kilometers from an excellent harbor, and the district is only a day's run by steamer from Manila.

COSTS.

It is very difficult to obtain any fair estimate of the working costs, even of exploration work, in the present state of the district as, except in a very few cases, no work has been done at any considerable depth and accurate cost sheets have not been kept. Besides this, all the work has been done under the supervision of one man for each property, and this has kept the expense for superintendence lower than will be the case when work begins on a larger scale.

[1] A voyage around the world. By John Franci Gemelli Careri (1695–1698). Translated from the Italian. Published in a collection of voyages by Awnsham and Churchill, London, 1704.

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Through the courtesy of the various miners of the district, I am able to give the following figures, in Philippine currency, for exploration and development works:

	Cost per foot.
Tunnels	₱4.00–₱8.00
Raises	6.00–12.00
Shafts	12.00–30.00

Small open cuts, from ₱0.03 to ₱0.06 per cubic foot.

Mr. Eveland, formerly superintendent of the Eastern Mining Company, states in his report on the property as follows:[2]

Although but few figures are available for the cost of operation of mines, mills, and of ore treatment, under the conditions in the Philippines, it can safely be said that ₱5 ore can be handled on this property at a profit and anything above that will be clear gain. There are no difficulties locally in the way of economic handling of material; in fact, conditions on the ground may be considered almost ideal for operation on a large scale, when extent and value are proven.

Certainly, a company operating on a sufficiently large scale and conservatively managed should be able to mine and treat ore at this figure or better. The ore is peculiar in that only a small per cent can be amalgamated, probably because of the large proportion of manganese oxide which it contains. Tests made by different laboratories in the United States showed from 25 to 33 per cent of the values recoverable by amalgamation, and it is very probable that in actual practice this would be further lowered. On the other hand, a large proportion is readily recoverable through cyanide treatment, tests made both in this laboratory and the United States show the ore to be remarkably well adapted to this method.[3]

Work in the Aroroy district has been going on for a sufficiently long time to build up a class of fairly efficient miners, and at present the local supply is sufficient for the demand.

The wages paid in the district are: For miners, laborers and muckers, ₱0.60 per day if food is furnished, or ₱0.80 without food; foremen, blacksmiths, etc., from ₱1 to ₱2 per day.

During the next two years, when several companies start operations on a large scale, there may be a temporary shortage of labor, but I do not expect any permanent trouble from this cause, as men are beginning to come in of their own accord from northern Panay and Sibuyan and there should be no great difficulty in importing other labor if it becomes necessary.

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[2] Far Eastern Review (1907), 3, 333.

[3] Mr. Eye, superintendent of the Colorado Company, plans to do away with the plates entirely in the 20-stamp mill which that company is preparing to erect and have the stamps crush in the weak cyanide solution.

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Mr. Berkenkotter, the manager of the Syndicate Mine, tells me that under average conditions nine men working three to a shift six days in the week, and doing their own mucking, can advance a tunnel 1 meter per day in porphyry and one-half meter per day in hard, fine-grained rock.

TIMBER.

The ground in this district stands well, and comparatively little timber is required. The principal claims, with few exceptions, contain a large amount of excellent wood easily accessible. Molave, by far, the best timber for mining purposes, is found in considerable amount and other good woods are plentiful.

Mr. Herbert, of the Colorado Company, has kindly furnished me with the following list of the varieties: Molave (*Vitex parviflora* Juss.), Dungon (*Tarrietia sylvatica* Merr.), Cubi (*Artocarpus cumingiana* Trec.), Bansálaguin (*Mimusops elengi* L.), Matamata colorado (*Strombosia?*), Matamata blanco (*Strombosia philippinensis* Rolfe).

Woods available for temporary timbering, as for example in stopes which are eventually to be filled are: Lauan (*Shorea* sp.), and To-og (*Bischofia javanica* Bl.)

These timbers have been given in the order of their preference.

The following average prices, in Philippine currency, are now being paid for timber:

First group, one piece 7 feet long, squared 7 inches (in some cases only molave accepted)	₱1.00
The same, rough	.75
Logging (molave boards or poles of other first-group wood)—per running foot	0.01–0.02
Ties 4 feet by 4 inches by 4 inches—each	.10– .12

The entire central range of the island is heavily wooded, and since there is a large amount of excellent timber just across the bay from Aroroy, there need be no fear of future shortage if reasonable care is taken.

POWER.

The feasibility of water power has not yet been determined. The Guinobatan runs nearly dry at times and it is doubtful, even with a large dam and reservoir, if it could be relied on as a source of water power. The Lanang, on the other hand, is a much larger river and has a more constant flow; although large floods are of common occurrence, it might be possible to furnish considerable power by constructing a dam at the upper gorge.

The mills and dredges in operation up to the present have used mangrove firewood under their boilers and have found it an excellent fuel. The cost delivered at the mine averaged ₱5 per cord, and it is estimated that 2 cords are about equivalent to a ton of coal. One company, more distant from the mangrove swamps, used wood cut from its claims, costing ₱4 a cord. However, this was less satisfactory than mangrove. If large demands were to be made on the

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mangrove swamps, the wood in the immediate vicinity of the streams would soon be cut off and the price consequently be increased, also if the regulation of Forestry Bureau, prohibiting the cutting of trees less than 15 centimeters in diameter is enforced, it would make the expenses of fuel greater. However, Philippine coal from the mine of the East Batan Coal Company, at present the only producing commercial mine in the Islands, is now selling at the mine for ₱6.50 a ton, and it eventually should be possible to deliver this coal at Aroroy at a figure which will give it preference over mangrove. The coal deposits on the Island of Masbate itself, at Dimas Alang and Kataingan, are dealt with in another article. Should these be found worth developing, then the fuel question will easily be solved. Coal deposits also exist on the Islands of Cebu and Mindoro, at no great distance from Aroroy.

COMMUNICATIONS.

Communication with Manila at present is by fortnightly steamship.

The freight rate for rice to Aroroy is ₱4 a ton. Since the completion of a fair road from Aroroy to the camp, making it possible to use carabao carts, the land transportation charges have been greatly reduced. Before the building of the road Mr. Eveland stated the rate to be ₱6 per ton from Aroroy to the Eastern mine; at present it is about ₱4. A further improvement contemplated is the change of the steamer landing from Aroroy to a point near Maguilangguilang Island, where a pier could be built and a road constructed to join the present one. This would shorten the land transportation by more than half.

A telegraph line is now being constructed from Aroroy to Masbate.

PLACER MINING.

In 1905 a dredge belonging to the Oriental and Masbate Dredging Company, was put on the Guinobatan River below the gorge. However, no exact prospecting or testing of the ground had been done, and the dredge was unable to reach bottom. The returns were small and the dredge did not run for more than a few months.

The dredge constructed on the Lanang River has had numerous difficulties, including severe damage to a pontoon by a typhoon, and has been idle since 1908. The ground is now being thoroughly prospected and if results are favorable it is probable that the dredge will be rebuilt. A promising field for placer mining which has not as yet been much prospected is the gravel beach lying up the stream from the first gorge of the Guinobatan.

The following is a brief summary of the more important work done in the district up to December 31, 1909. The Keystone Mining Company on Aroroy Mountain has two shafts in ore. These are connected by means of a drift, and a crescent tunnel from the southern side of the hill to meet the upper shaft is being advanced. The principal workings of the Colorado Mining Company consist of two adit levels connected by an inclined shaft in the foot wall 60 meters deep. From the second level there are foot-wall winzes. Crosscuts have been made at intervals on both levels. The Syndicate Mining Company, operating the claims of the Eastern Mining Company on Kalakbao Hill, has done development work on three claims. The earliest extensive work, on the Have Got claim, consists of a crosscut tunnel now caved at the surface, a raise to the surface and drifts. The Nebraska Star has a crosscut tunnel 60 meters long, a raise 30 meters to the surface, and 150 meters of drifts on four veins, and about 50 meters of crosscut levels; on the upper a crosscut tunnel cuts two veins and there are

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drifts, crosscuts, and a raise to the surface. The Aroroy Mining Company was organized last year and has taken over four groups of claims, including the property of the former Gold Bug Company. Operations so far have been rather in the nature of prospecting than of development. Considerable work has been done in constructing prospect tunnels, open cuts, etc., on the Gold Bug, California, El Sol, Montana, Gilt Edge and other claims. The Tengo Mining Company, successor to the former Mount Cogran Company, has begun development work in a systematic manner. The vein is now being crosscut in several places, and when sufficient ore has been blocked out, the mill will be put in shape for use.

Taken altogether, the district at the close of the year 1909 is in a more satisfactory condition than it ever was previously. This is the first time for several years that no production has been reported, but that of former years was premature and the gold was obtained at great expense. If the work in the district continues on the lines now being followed, production should begin again in another year, and it should not be long before several large and profitable mines are operating.

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GOLD PLACERS OF NUEVA ECIJA.

By F. T. EDDINGFIELD.

The gold placers of Nueva Ecija have not received much attention, although they have been known and worked for sixty years or more by foreign capital.

It is reported that a Spaniard, fifty years ago, worked placer ground at a point about halfway between Cabu and Peñaranda on the Sapang Bujoy. A map of Luzon, by D'Almonte, published in 1883 has marked upon it six points in this district where gold had been found, one on the Sapang Bujoy, two on the Macabaclay, two near the junction of the Rio Chico and the Sumagbac, and one near the head of the Santor or Cornell River. No further information about these points could be found; but these publications indicate that gold must have been produced in noticeable quantities.

An Englishman about 1890 did some work near the head of the Cabu River at Bakas. At that time also, a company was formed in Manila which started work on the Macabaclay with a crude sluice. Its operations were terminated by the insurrection of 1896 and no more work was done until Mr. Dorr, who had been employed by this company, resumed work in 1905. His operations are fully described in Mr. Goodman's report.[1] Very soon after Dorr's return two miners, Neill and Brown, worked the ground near the head of the Cabu, but with little success.

No other records of work done by white men previous to 1909 could be found; but natives have worked the gravels for ages by hand panning and hundreds of them at present have no other occupation. They resent the influx of Americans and do not try to conceal their dislike. Their attitude recently has been so hostile that precautionary measures were taken by the Constabulary in the district.

A number of men from Manila this year have formed a company and located claims on almost every stream between Cabu and Gapang. They tested the ground near Peñaranda with a boring machine and will undoubtedly test many more of their holdings in the near future. These boring tests were reported as showing 33 centavos per cubic yard. Pan tests in other localities gave much higher values, ranging from 50 centavos to ₱1. Such ground when worked on a suitable scale will give good returns on the money invested.

One of the most interesting features in all parts of this region is the presence of platinum in small quantities. The natives were ignorant of its value and always threw it away when they separated it in their pans.

[1] Far Eastern Review (1907), August.

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It is probable that iridium or other rare metals may also be found, as Mr. Goodman states in his article. The only other region in the Philippines where platinum has been encountered is at a point about 40 miles south of the Nueva Ecija district, and the indications are that both deposits are derived from the same source.

The gold is bright yellow and is reported to be 958 fine. It occurs almost unvariably in thin disks or flakes, varying in size from a fine dust to rare fragments as large as a 10-cent piece; the general run is about the size of flattened bird shot. This would lead to the assumption that the gold came from a schist or gneiss, or a much-squeezed quartz vein. The only rock of this character so far reported in this region is the gneiss mentioned by Mr. Goodman, but extensive exploration has never been made.

The area in which paying amounts of gold can be found is very large, extending from the Eastern Cordillera to the Rio Grande de Pampanga, between the Santor River and a line 6 miles south of the Rio Chico, about 600 square miles. There is a bed of sand and gravel which seems to cover this entire area, possibly produced by constantly shifting streams. This explanation of the origin seems more probable because of the great number of streams which seem to head from about the same source in the eastern Cordillera, and all of which carry gold even to their mouths. These streams are the Rio Chico, Ilog Muntí, Sapa Palanao, Cornell or Santor, Mayon, Macabaclay, Pagsanjan, Calabasa and Cabu, which flow into the Rio Grande.

Assuming the Eastern Cordillera between the head of the Cabu and the Santor to be source of the gold, then similar placer ground probably occurs on the eastern slope of the mountains as well, possibly on the Ibonan River. This possibility has never been thoroughly investigated, partly because of the warlike people, termed Mambulaos and Ibilaos, who live in the hills surrounding. This assumption regarding the origin differs from that made by Mr. Goodman, who placed the source of the gold in the Caraballo Sur. A layer of clay called a "false bottom," which overlies another bed of pay ground, is located underneath the gravel bed which carries the gold. The total distance to bed rock varies from 8 to 13 meters in general, but near the head of the Cabu it is very small and in a great many places the water has cut through and worn a channel in the bed rock. A mining man from that point reported the bed rock to be lava. Mr. Goodman discusses this in greater detail.

Black sand is found everywhere in large quantities, and its presence might prevent the successful exploitation of a great part of the ground.

Mr. Neill, who has worked the ground near the head of the Cabu, found it necessary to clean up his riffles once every three or four hours. Further down, however, the percentage of black sand diminishes, and the ground near the mouth of the Cabu and at Peñaranda is considered very promising. Mr. Neill states

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that the gold floats on the water and a large percentage is lost; and that because of its physical condition it will not amalgamate unless altered by some preliminary treatment; besides this, the clay is very troublesome and necessitates considerable washing. These difficulties might be overcome, but a great one would be encountered in the wrecking of a dredge which might be washed away by floods, or typhoons, which occasionally occur and from which there is no apparent protection. Furthermore, during the dry season most of the streams are practically without water, so that good dams would have to be built to hold the quantity which does flow.

In other respects the district is well situated for dredging. It is near a railroad so that supplies can be readily obtained and it is near good forests where suitable timber for construction can be found.

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OTHER DISTRICTS (GOLD).

By FRANK T. EDDINGFIELD.

Catanduanes.—Interest has lately been revived in the gold deposits of this island. Prospectors from the Paracale district have recently visited and explored it, reporting very favorably on the prospects. They found evidence of former mining by Spaniards or natives in the northern part, and this is usually an indication of rich deposits. Some placer ground was also found which might prove to be profitable. Coal deposits were also reported.

Ilocos Norte.—One prospector, Mr. Burdette, has located a gold vein east of Bangui and is at present exploring and developing it. So far no rich deposits of gold have been found in this province, which heretofore has been known chiefly for asbestos, manganese, and guano.

Mindoro.—Mindoro has been explored by several prospectors during the last few years, and a company was once formed to work some of the ground. Placer deposits are found on the west and north coasts, some of them are said to be suitable for sluicing. Very little is known of the geology of the interior of this island.

Mindanao.—The country around Surigao for several years has been prospected for gold at intervals and recently two miners worked some ground for a short time, with fair returns. The placer ground is said to be very good and the gold very coarse, but conditions have been unfavorable and prospecting in the interior dangerous. Several prospectors are at present again testing the ground.

Placer ground has long been known near Cagayan de Misamis on the Cagayan, Iponan, and Pigholugan Rivers. Old Spanish reports of 1877 speak of these localities. Recently two parties have been relocating the ground and testing it with boring apparatus.

Pangasinan.—For the past year or two the copper deposits of western Pangasinan have been neglected by prospectors as their energies have been directed toward the gold deposits in the eastern part of the province near Binalonan and Pozorubio. Manila capital has become interested in some of these prospects and it is the intention to develop them.

Tayabas.—Two prospectors, Messrs. Bode and Villiger, have located a number of claims near Guinayangan. They state that they have found several good gold-bearing veins and a large area of placer ground. The gold brought from these placers is fairly coarse and of a good color. This district is directly opposite Paracale, across the tail of Luzon and may be in the same mineral belt.

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THE MANCAYAN-SUYOC DISTRICT, MOUNTAIN PROVINCE.

By FRANK T. EDDINGFIELD.

The deposits of Mancayan, as is the case with all the others in the Philippine Islands, have been worked for years past by natives, in this case by Igorots, possibly by Chinamen, and to a very large extent by Spaniards.

The natives extracted the copper from the ore by a laborious process, and manufactured most of their cooking utensils from it. They also became quite expert in making counterfeit copper coins which were used even after the Americans took possession. The Spaniards worked out huge rooms and cavities in the Santa Barbara mine, taking out only the very rich ore found in stringers and pockets, which ran from 40 to 60 per cent of copper. This ore was smelted in crude furnaces at the mine; probably less than 50 per cent of the copper in the ore being recovered.

These deposits at the present time, at the points opened up, seem to show the characteristics of a quartz-porphyry in one case and an andesite in another, both of which have largely been replaced by silica, fractured by subsequent action and enriched along the fissures thus made with secondary copper, which may be supposed to have come from a copper-quartz vein somewhere in the formation.

There appear to be three bodies of ore varying from 18 to 150 meters in width. These bodies run parallel and only about 100 meters apart; they can be traced for about 4 kilometers on the surface in a northwest-southeast direction from the foot of the hill north of Mancayan to Pocta Creek and beyond. Pocta Creek cuts the three veins which stand out with great distinctness above the bed of the stream. It is here that the character of the deposits is best seen.

The values are unevenly distributed throughout the bodies. In one case a strip 40 meters wide on the eastern part of the ore body carries 2 to 3 per cent, while the remainder of a total width of 130 meters is barren. Another section has about 2 per cent for its entire width of 130 meters.

The Santa Barbara is the only property on which mining has been done. From 2,000 to 3,000 meters of tunnels and drifts has been driven in this deposit by the Spaniards and the American successors to the property. The Spaniards must have taken out several hundred thousand tons of ore, working only the

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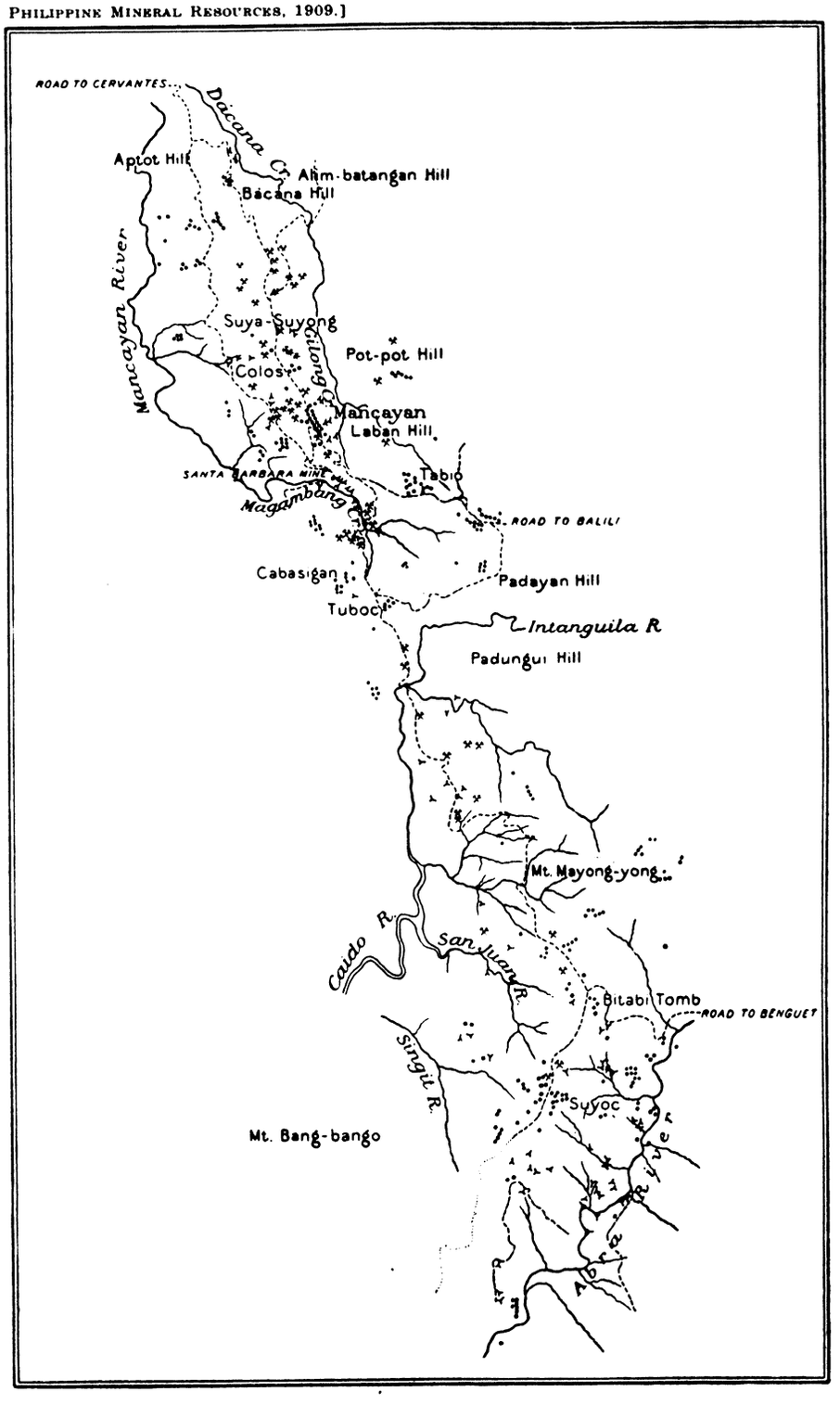

PLATE VII. MAP OF MANCAYAN-SUYOC DISTRICT.

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rich stringers and pockets. These stringers contain tetrahedrite, bornite, luzonite, chalcopyrite and some oxides. The stringers vary in width from a few centimeters to over a meter in some rare cases, and strike at an angle of almost 30° to the main body, although one or two veins lie parallel to it.

There are five levels embracing a vertical height of over 60 meters. The lowest of these, the drainage tunnel, has over 300 meters of development. A crosscut in the north end exposes some very rich ore in what appears to be a rather large pocket. Small stringers are also found at various other points on this level. This point is emphasized because of a contrary statement which appears on page 51 in *Bulletin No. 4* of the Mining Bureau, by Mr. Eveland, who was unable to reach all parts of this level on account of the condition of the drifts.

Some claims, owned by Mr. Gaffney, lie to the north of the Santa Barbara. He has done about 500 meters of development work on seven of these claims, exposing some very good low-grade ore. In the "Oriental" claim he has cut 20 meters of ore.

South of the Santa Barbara are properties owned by Messrs. Chambers, Muller, Wright, and Pettit on which more or less work has been done. Messrs. Chambers and Muller have cut an ore body 160 meters wide, said to carry 2 per cent of copper, which appears to be the central body of the three. Some work has also been done on the outcrops on Pocta Creek. South of this but little copper has been found.

Numerous veins which carry gold, silver, and some copper occur at Suyoc. They are in general true fissure veins with quartz filling, 1 to 6 meters wide, occasionally having stringers of calcite along the walls, and they are said to carry from $10 to $50 per ton in gold alone. The gold appears for the greater part as a telluride, but it occasionally is found free, and associated with zinc, lead, copper, iron, and manganese.

The veins are found in conglomerate, in diorite, in andesite, and in andesite-breccia. The fissuring seems to have occurred after the formation of sedimentaries and was probably caused by the intrusion of the Bagan granite which lies to the west.

The values which are encountered in stringers of rich ore could readily be concentrated. The "Elizabeth," "Anaconda," and "Quien Sabe" are all properties that show great promise.

The ore, both copper and gold, seems to call for concentration and smelting by the usual class of mill and smelter suitable for the purpose. Cyaniding might be used with the gold ores, although their high copper content seems prohibitive.

The Mancayan copper deposit will be workable by quarrying for a great many years, but the gold veins will need to be mined in the usual way because of their width. However, the work should be cheap since so great a depth can be reached with drifts or tunnels.

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THE BULACAN IRON DEPOSITS.

By WARREN D. SMITH.

There has been no change in the methods of smelting since Mr. McCaskey's visit in 1903, whose account [1] is so complete and accurate that I shall refer readers to it for a full discussion.

The ore used is high-grade hematite which the natives find on the surface, or quite near it; it is dumped into a crude fire-clay furnace with charcoal, but *no* flux is used. By means of a large, hollowed tree trunk, containing a piston operated by one or more men, a very unsatisfactory blast of air is produced. The metal and slag run out of the same opening, the slag first, followed by the metal. The latter is then poured into small fire-clay molds for plowshares. These are then packed by carriers down to Angat and from there distributed all over Bulacan and neighboring provinces.

The Hison mine, which has been longest and most successfully in operation, is owned and operated by Doña Maria Altesa Fernando, of Angat, so that the only really successful iron furnace existing to-day in the Philippine Islands is owned and managed by a Tagalog woman.

During 1909 Maria Fernando made and sold over 36,000 pairs of plowshares. Although the insurrection and a costly lawsuit at one time nearly wrecked her business, she has kept on and is making sufficient money to rehabilitate herself and in addition to educate her younger brother in Manila as an engineer.

In addition to the two furnaces operated by Doña Maria Fernando, there are three new claims on which furnaces have been erected, but they are not as yet well started. I have not seen them. Sr. Infantado has produced a few tons of metal this year, but his furnace was not running in 1909.

I wish here to record the result of my own very limited observations in addition to the remarks by Mr. McCaskey regarding the occurrence of the ore. The ore is found in the massive crystalline rocks of this region, which are in the main dioritic and andesitic. The iron ores, hematite, magnetite, etc., are alterations of these crystalline rocks in place. They are not sedimentary deposits, and therefore any regular strikes and dips, such as occur in sedimentaries, would not be found. The iron deposits,

[1] Bull. No. 3 of the Mining Bureau.

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as far as I was able to make out, have absolutely no connection with the later sedimentaries. The diorite is very rich in ferromagnesian minerals, with an unusual amount of iron pyrites and chalcopyrite which have gradually yielded their iron to the percolating ground water traveling along fractures. The present deposits in my opinion represent merely a segregation of iron oxide resulting from decomposition of the above-mentioned minerals.

Considerable stripping and diamond drilling will be necessary to prove the value of these deposits.

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OTHER METALLIC MINERALS.

By HENRY G. FERGUSON.

Besides the gold deposits already described, the Philippines are known to contain deposits of copper, argentiferous lead, iron, and probably other minerals as well. However, up to the present time, the limited capital available has naturally been turned first to gold, but now that gold mining promises to be a good investment, we may expect development along other lines.

COPPER.

The copper mines of the Mancayan-Suyoc area in the Lepanto subprovince of the Mountain Province have been described separately.

Mention was made in our last annual bulletin of the deposits of native copper and copper sulphide near Milagros, Masbate. No work has been done on these during the past year and there is no immediate prospect of further development. Many of the gold ores, particularly those of the San Mauricio Company, in Ambos Camarines, contain a considerable proportion of minerals carrying copper; these will be shipped to smelters as concentrates.

The following is a list of provinces in which copper ore is known to occur:

Ilocos Norte, in the northern cordillera.
Ilocos Sur, in Abra subprovince.
Mountain Province, in Lepanto and Benguet subprovinces.
Pangasinan, in the vicinity of Salasa.
Zambales and Bataan, at different points throughout the Zambales cordillera.
Batangas, in the Loboo Mountains.
Tayabas, in the central range near Atimonan.
Ambos Camarines, in the vicinity of the Paracale-Mambulao gold district and on the Karamoan Peninsula.
Mindoro, in the northern part.
Marinduque, near Torrijos.
Masbate, in the main range of the island, east of Milagros.
Samar, on the small island of Kagul.
Misamis, in the region south of Cagayan de Misamis.
Surigao, in connection with the gold ores.
Moro Province, on the Island of Sulu.

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SILVER AND LEAD.

All the gold won in the Philippines is alloyed to some extent with silver; the proportion varying from less than 5 per cent in the placer gold of Paracale to 30 per cent in some of the gold mined in Benguet.

The principal occurrences of silver-bearing galena are: The vicinity of Paracale, Ambos Camarines; the Catarman peninsula in the same province; the Island of Marinduque, near Torrijos; Masbate, near Milagros; and Cebu, near Mount Acsubing. All of these deposits have been prospected to some extent, but at present work is being carried on only in the Marinduque field.

MANGANESE.

Deposits of manganese oxide occur in Ilocos Norte, near Bangui, and on the Island of Masbate in the Aroroy gold district. The deposits of Ilocos Norte have been thoroughly prospected and development work may be undertaken in the near future. It is planned to spend a small amount of money on the immediate prospecting of the deposits in Masbate and should this show favorable results, development work will be begun.

OTHER METALS.

Platinum has been found in small amounts in the auriferous sands of Nueva Ecija. Zinc blende occurs in the gold ores of Ambos Camarines and associated with the lead deposits of Marinduque and Masbate. Specimens of stibnite have been brought to this Bureau from Bataan and Batangas Provinces. Molybdenite has been found in Batangas and Ambos Camarines. The Negritos from the region around Mount Isarog, Ambos Camarines, are said to collect small amounts of native mercury, and only very recently cinnabar has been discovered in Benguet. Native arsenic has recently been encountered near Bugias, Benguet.

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PHILIPPINE COAL.

By WARREN D. SMITH.

After nearly a decade of prospecting and preparation under the new régime, including a number of false starts, two coal mines are now in operation in the Philippine Islands. These are both situated on the small island of Batan, Province of Albay, Luzon.

Coal in the Philippines occurs with Tertiary shales and sandstones on nearly every island of the Archipelago, with the greatest development in the Visayas. The coal is classed as sub-bituminous. The highest percentage of fixed carbon yet recorded is in a sample from the old Compostela mine in Cebu, 54 per cent. The coal is invariably low in ash. It has been found satisfactory for ordinary steaming purposes when burned on proper grates and with care in firing. The seams range from a few centimeters to 4 meters in thickness. They are usually, with the exception of those on the eastern part of Batan, inclined at all angles up to the vertical and are more or less faulted. The roof as a rule is firm and the cleats are good. The most favorable mining conditions so far found are on the eastern end of this island.

The principal localities in the Archipelago are as follows:

Location.	Province.	Island.
Batan Island	Albay	Luzon.
Sugod Bay	do	
Near Compostela	Cebu	Cebu.
Near Danao		
Polillo Island	Tayabas	Masbate.
Cataingan	Sorsogon	
Dimas Alang		
Bulalacao	Mindoro	Mindoro.
Silay River, Sibuguey Bay	Moro	Mindanao.

Coal was first discovered in the Philippines in 1827 on the Island of Cebu, the nearest approach to a successful coal mine during the Spanish régime being on that island. In 1904 the United States Army began development work on the western end of Batan Island, and in the fall of 1905 work was started on the East Batan Coal Company property. It

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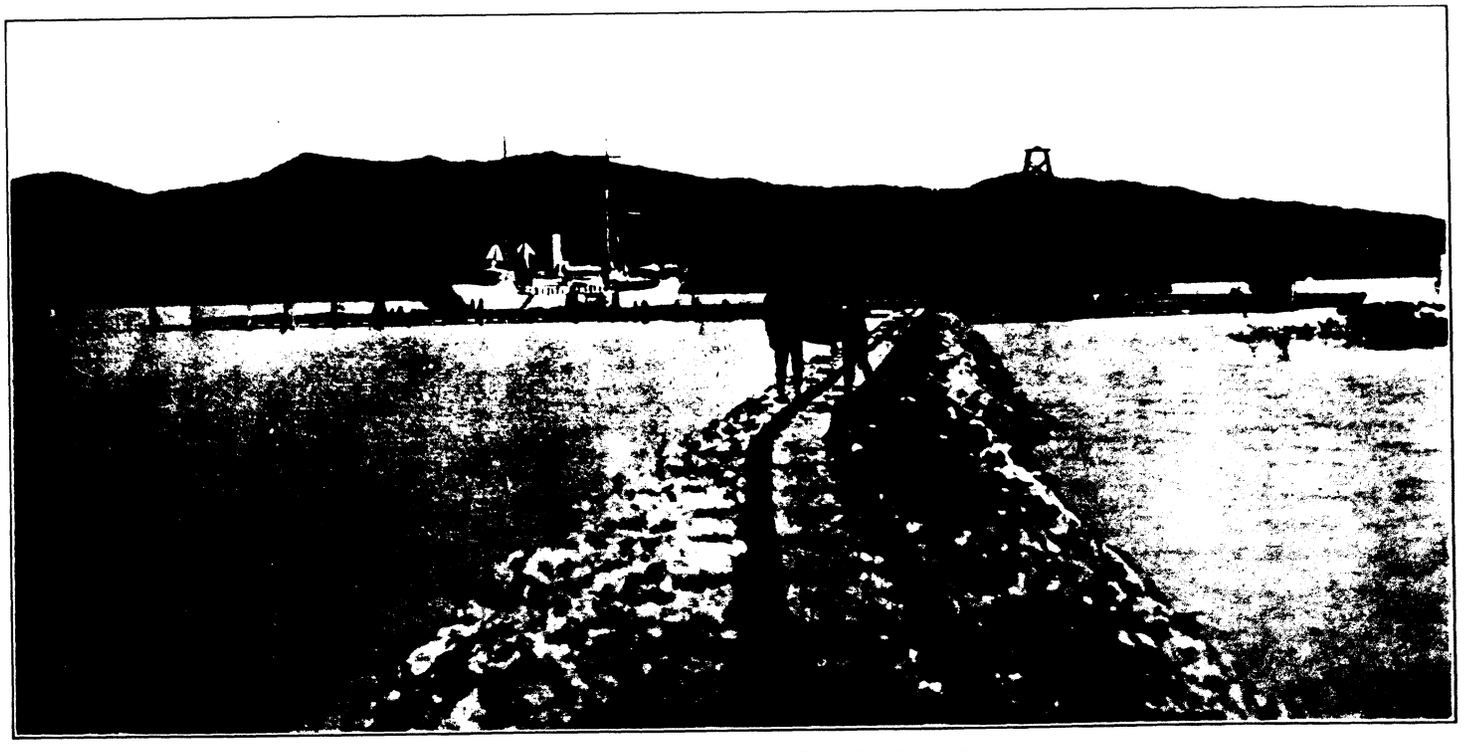

PLATE VIII. THE NEW DOCK, EAST BATAN COAL CO., BATAN.

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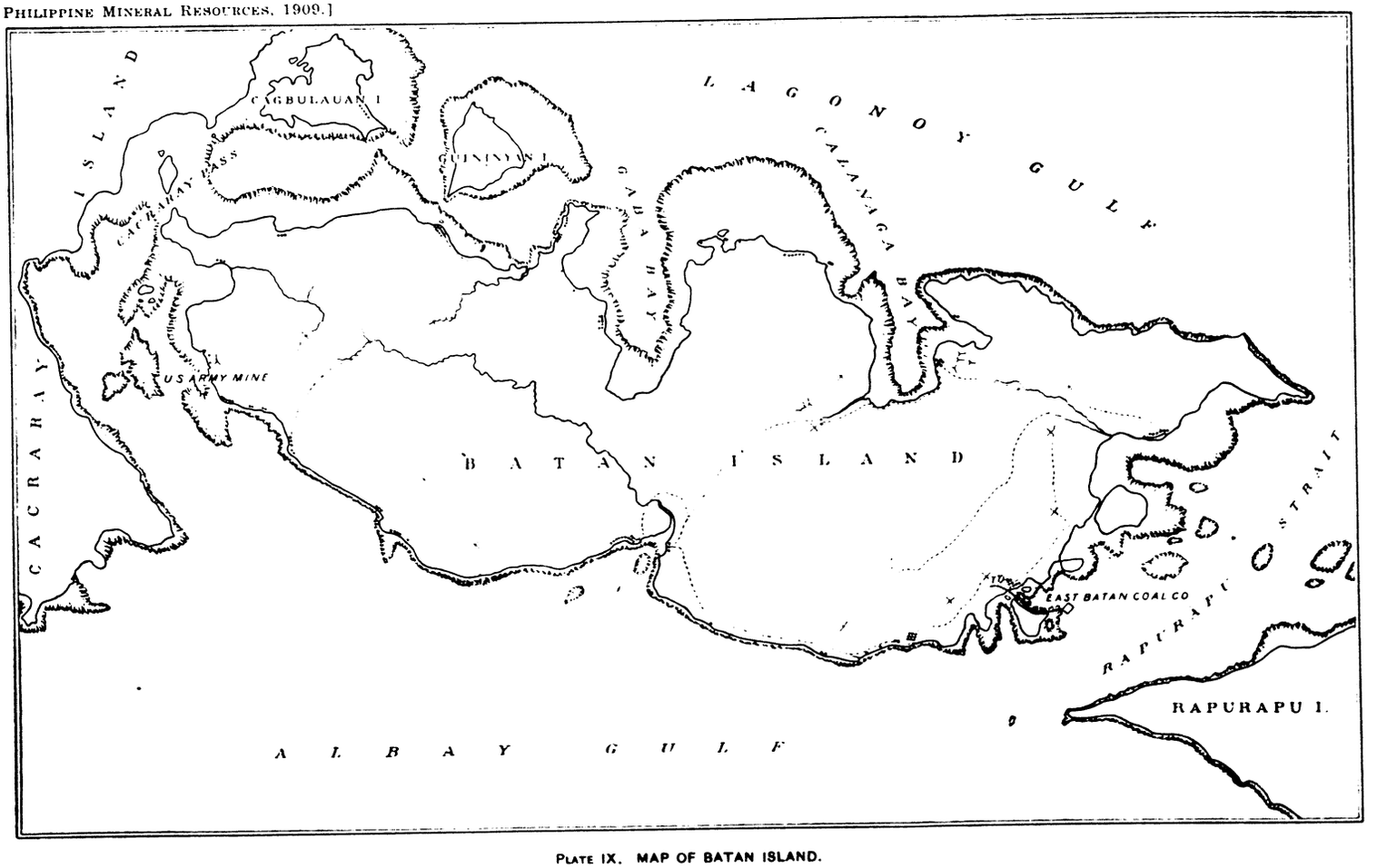

PLATE IX. MAP OF BATAN ISLAND.

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is understood that operations will soon be resumed on the old properties near Compostela and Danao, on the east coast of Cebu. Vigorous exploration was recently begun in the eastern portion of Masbate Island, but in the other localities little is being done at the present time.

COAL IN ALBAY PROVINCE.

The coal industry in the Philippines has now passed beyond the stage of prospect. Development and production have begun.

Development work will soon be renewed on the old Spanish properties near Bacon in Sugud Bay. The coal seams should easily and profitably be worked in that locality, as very little indication of extensive disturbance appears on the surface.

The only present coal production is from the mines on the Island of Batan, off the Albay coast. The Cebu properties remain in about the same condition they were in at the beginning of 1909.

THE UNITED STATES ARMY COAL MINE.

This mine, is located on the west end of the island at Liguan (see map). Approximately 2½ kilometers of galleries, including entries, headings, crossholings, rooms, etc., have been opened up; these are confined to three principal seams, of which the uppermost at present furnishes the coal. This seam, outcropping at an elevation of 60 meters above sea level, is 1 meter thick; it is dipping at an angle of 45° to the northwest.

The two longer ones are 40 feet apart and are, respectively, 1.54 meters and 1.33 meters in thickness. The measures at No. 4 entry on the upper seam, which is at present being used, are marked by a coarse grit or conglomerate full of quartz pebbles, both above and below the coal. This occurrence has not been noted in the coal measures on the eastern end of the island. This coal is quite firm and is superior in appearance to the Japanese coal sold in Manila. Recent steaming tests show it to be better for steaming.

As was predicted in 1905, a number of small faults and rolls have been encountered. From my recent examination of the mine I do not think that these are so serious as to make the operations unprofitable; but it is clear that the mining of coal on this end of the island will call for the most experienced engineering ability.

Since our last report 198 meters of new dockage and a 2,000-ton bin with double tracks connecting it with the dock have been built.

The output with hand labor varies from 60 to 80 tons a day. This, however, is not regular.

During the past year 6,000 tons were taken out and supplied to various vessels of the Army and Navy.

THE EAST BATAN COAL COMPANY.

A number of changes and improvements have been made at this mine.

The most important is the abandoning of the old and wasteful Japanese methods. With the arrival of Mr. Davy, a man experienced in underground work, the mine is being rapidly put into up-to-date condition. The old method of working to the

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dip and robbing the ribs has been abandoned. It has been found that after the first 30 centimeters of the roof scales off, the rest stands with only a row of props, so that henceforth an immense amount of timbering can be avoided. This roof has a tendency to arch itself, and it is quite likely than even props in the haulage-ways can be dispensed with.

Since our last report 883 meters of new track have been laid, connecting the mine with a new dock on which a very ingenious loading tower which travels on a track the whole length of the wharf has been erected. The tram cars have side doors, by means of which the coal is emptied into the loading bucket which is hoisted up to the required chute. There are four of the latter from which the coal slides into the ships' bunkers. The superintendent plans to change this system so that the tram car itself will be hoisted, thus obviating one handling of the coal. This loading tower is 14.5 meters high. The bucket holds 1 ton. The tram cars have a capacity of 2 tons. Other improvements are the digging of a new sump in the mine and the installation of an Emerson pump with a capacity of 757 liters a minute. A new 70-horsepower boiler is also being installed.

There are in all 6,096 meters of galleries, the main entry 295 meters at an angle of 15°, but 40° off the dip.

Although the production is not regular the average output is now 150 tons a day; when the present changes have been completed this will be increased to 200 or 250. It should be remembered that as yet no machines have been used. Mr. Daniels, manager, contemplates the installation of compressed air drills, mule haulage, electric lights, and a number of other improvements within the year.

The coal pockets which the Civil Government proposes to erect here have not yet been constructed. They will be a very desirable addition to the plant.

The conditions for economical mining on this end of the island are very favorable. The coal seam now being worked is 1.7 meters thick and is perfectly uniform, seemingly without a trace of faulting and only a slight tendency to roll. It has fine face and butt cleats, so that there is no need of powder, nor has any accumulation of gas been noticed. If more efficient labor could be had the conditions would be ideal for long-wall mining. The method employed now is the "room and pillar."

This company as it is now organized with Mr. Daniels as general manager and Mr. Davy in charge of the underground work has every reason to expect a successful future. One shipment of coal from this property has recently been sold in Hongkong and another in Singapore. Tests on the briquetting of this coal will shortly be made by the United States Geological Survey at its Pittsburg office.

COAL IN CEBU.

The geology of the Island of Cebu was summarized by me in my paper on this region published in 1907.[1]

The complete history of the discovery of coal and operations in Cebu is given by Mr. Burritt in "The Coal Measures of the Philippines"[2] which is a compilation and translation from the Spanish records, a brief summary will therefore suffice for this bulletin.

[1] *Phil. Journ. Sci., Sec. A* (1907), **2**, 377.

[2] Report to the United States Military Governor in the Philippines. Washington, 1901.

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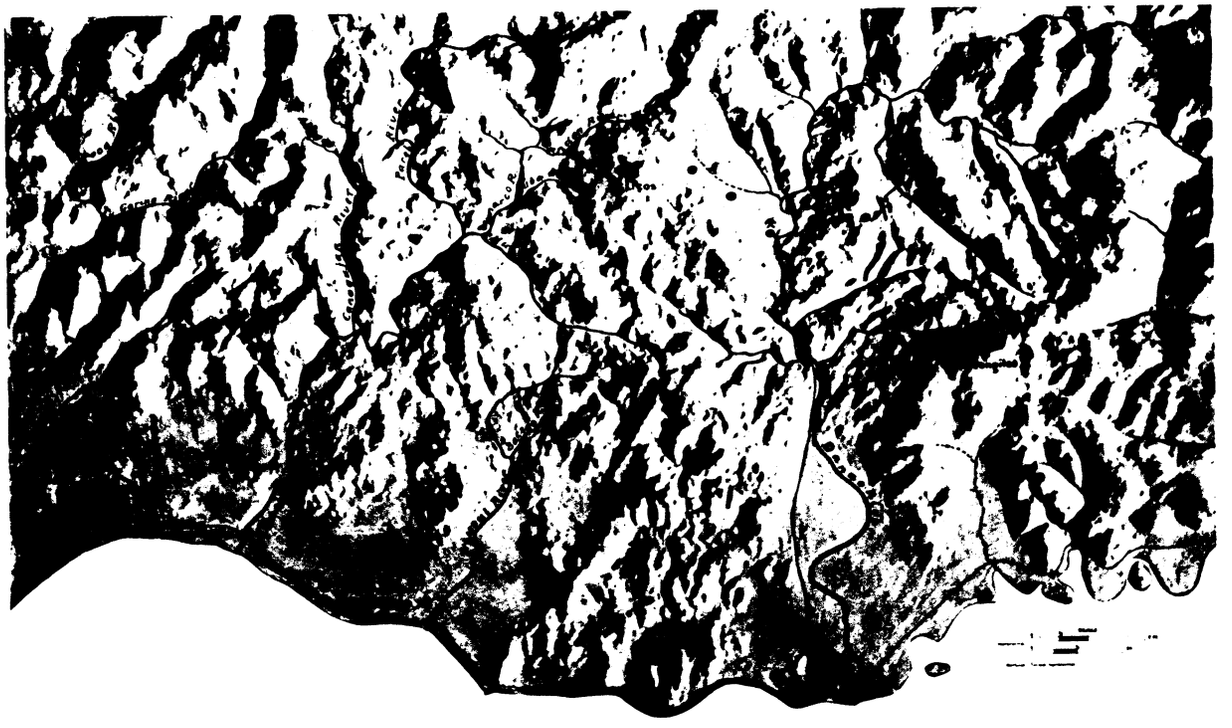

PLATE X. RELIEF MAP OF COMPOSTELA FIELD.

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Coal was discovered in Cebu in 1827. The first concessions in the Compostela-Danao region were solicited by Isaac Conui in 1871. A wagon road was built from Cot-cot cove to the workings at Dapdap in 1877. The formation of the association known as the Sociedad Nuevo Langrea and the beginning of actual work took place about 1890. The construction of a tramroad from Danao to Camansi, and from Compostela to Mount Licos, was undertaken in 1895. The Spanish-American war in 1898 occurred. In this year all the concessions in this district came into the hands of Mr. Enrique Spitz. These have changed hands again and are controlled by the Insular Coal Company, which is now in the field carrying on exploratory work.

In 1907 and 1908 two companies were engaged in vigorous exploration of this field, the Insular Coal Company in the Mount Licos and Camansi region and a New York syndicate in the Cumayjumayan Valley, but there has been no further work. It is understood that negotiations are under way for the formation of a large company to mine this coal in the very near future.

The district is one in which the geology is very complicated, but not more so, it is believed, than in the other coal-bearing areas of the Archipelago. It certainly has some features possessing advantages over other parts of the Island of Cebu, where coal may be found in almost all parts.

During the last year Mr. Mitkaiwicz, in one locality in the Minanga Valley, did some development work. A sample taken by myself from the dump was found to form a not very firm coke.

COAL SEAMS.

The three fields at present being developed are rather limited, but amply sufficient for a considerable production of coal. A very conservative estimate of the possible tonnage would be 2,000,000 workable tons in the Cumayjumayan Valley and two to four million in the combined Mount Licos and Camansi fields. The coal seams are inclined at angles from 30° to 90°. There is evidence of considerable minor faulting, but probably none which will seriously affect mining operations. Five coal seams are known, at least three of which should be profitable, two of these are over 3 meters thick in one part of the field. The following beds were encountered at Mount Licos, from west to east, that is from lowest to highest:

(1) The "Carmen;" thickness 1.60 meters, strike northeast-southwest, dip 30° southeast; 40 meters interval.

(2) "Esperanza;" 50 centimeters, strike the same as above, dip the same; 9 meters interval.

(3) "Enrique Abella;" thickness 1.20 meters, strike north 23° east, dip 40° to southeast; 40 meters interval.

(4) "Pilarica;" thickness 1.40 meters, strike north 23° east, dip 30° southeast.

Over 300 meters of drifts formerly existed at the old Licos workings. About 100 tons of coal, taken from the "Esperanza," "Ramoncita," and "Enrique Abella" galleries have been on the dump for three or four years. In this time the coal has not taken fire, nor has it "air-

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slacked" very greatly, good signs for its handling and storing. The coal throughout the district is remarkably free from dirt, "butter" and "bone" and is quite low in sulphur.

Dr. A. J. Cox, of the Chemical Laboratory, Bureau of Science, has discussed the composition of the coal in various papers.[3]

LABOR.

Labor conditions on the whole are good in Cebu and in the Compostela-Danao district the natives have more or less familiarity with underground work, gained by experience of a score of years under the tutelage of the Spaniards. The present wage in this field is 40 centavos and subsistence for the outside laborers, and 50 centavos for the underground men; however, of late the Insular Coal Company has found it best to pay by the foot in drifting. The price per foot will of course vary according to conditions. The Philippine Railroad Construction Company has found the native labor to be very satisfactory. In their work thousands of natives were used at a wage of 50 centavos and subsistence. The subsistence was arranged for by contract with a Chinaman.

TRANSPORTATION.

The new railroad from the city of Cebu to Danao, a distance of 32 kilometers (20 miles), is completed at this date. From Danao to the Camansi workings is a distance of about 8 kilometers (5 miles) with a rise of 75 meters (250 feet). There is now a tramroad over this course, an heirloom from the Spanish régime; but this will need to be replaced by new rails and more clearing will have to be done before any extensive work is undertaken. The transportation problem in the other parts of the district will not be so simple, and I believe overhead cables or inclined planes will be found to be necessary.

[3] *Phil. Journ. Sci., Sec. A* (1906), 877; (1907), **2**, 41; (1908), **3**, 91, 301; (1909), **4**, 171.

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COAL IN THE CAGAYAN VALLEY.

By HENRY G. FERGUSON and R. N. CLARK.

Coal has long been known to exist in the Cagayan Valley in the vicinity of Alcala, and in September, 1908, we had the opportunity of visiting several of the outcrops.

The first of these is near Baggao, a small town about 10 kilometers up the Paret River, a stream joining the Cagayan at Alcala. The coal outcrops in a small brook called the Wawing, about 3 kilometers north of the town. Here the seam is about a meter in thickness.

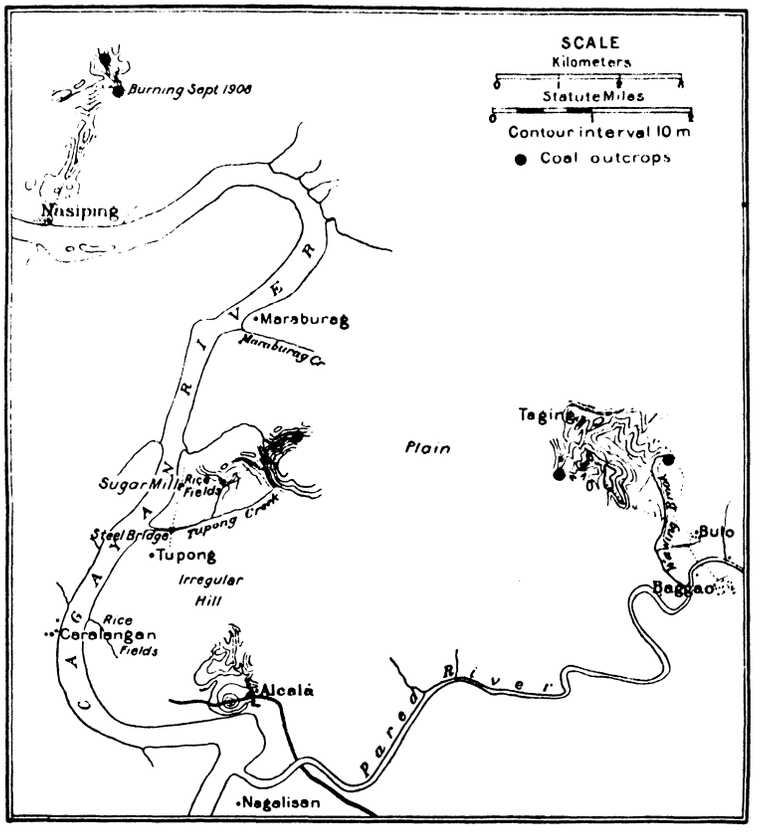

FIG. 1. COAL OUTCROPS IN CAGAYAN VALLEY.

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About 2 kilometers west of this outcrop, coal occurs in the bed of a small stream flowing north. It was not possible to gauge the thickness of the seam here, but in all probability it is no greater than the first one we visited. There is said to be better coal farther up the Paret River in the San Jose Valley, near the barrio of Taytay.

To the northeast of Nasiping stretches a range of low, grass-covered hills among which the coal beds are located. The first bed visited lies north 35° east of Nasiping and 2.5 kilometers distant; the elevation by aneroid being 95 meters above the Cagayan River.

About 2 kilometers to the northeast of the steel bridge across the Tupong Creek and about 4 kilometers north of Alcalá an outcrop was found in the bed of Tarya Creek, barrio of Maasin, and 45 meters above the Cagayan River. The coal at this place strikes north-northeast and dips 30° to the west-northwest. Directly above is a layer of black clay and below a lighter colored variety. The coal seam is but 0.5 meters in thickness.

The following analysis of this outcrop coal was made by Dr. A. J. Cox, of the Bureau of Science:

	Per cent.
Water	19.3
Volatile combustible matter	38.8
Fixed carbon	30.3
Ash	11.6
Total	100.0

If we consider the poor quality of the coal and the thickness of the seams, together with the distance from Manila as well as the scarcity of labor, it will be seen that this coal probably will never become available for the Manila market. However, there is no reason why the river steamboats could not save a large part of their coal bills by using it mixed with Australian, and it might be possible, if developments should show improvement in quality and continuity of seams, that steamers calling at Aparri would find it profitable to take part of their coal at that port instead of at Manila.

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MISCELLANEOUS NONMETALLIC MINERAL PRODUCTS, PART I.

By GEORGE I. ADAMS and WALLACE E. PRATT.

STRUCTURAL MATERIALS.

The information secured concerning the production of nonmetallic minerals during the calendar year 1909, is considerably more complete than that which was published last year, when the first attempt was made to gather statistics concerning these products.

Through the courtesy of the Director of the Bureau of Education, permission was obtained to send schedules to the supervising teachers throughout the Islands asking for estimates of the amount of sand, gravel, crushed or broken stone, building stone, lime, brick and tile, pottery, clay, and salt which was produced in their districts. The answers received for the most part showed that considerable interest and care had been given to the filling of the schedules, and in some cases valuable information was included which was not asked for by the questions on the blanks.

This method of collecting statistics, even when fully carried out, is defective, since there are parts of the Islands in which no schools are maintained, notably in parts of Mindanao and the Mountain Province. Moreover, most of the production is the result of intermittent industry and some products are made by household industry for immediate use and consumption, so that it is difficult to obtain accurate figures concerning the total value of the products. In some cases the articles have no local market value since they are exchanged by barter.

The principal production and use of stone, gravel, and sand has been by the Bureau of Public Works, the United States Army engineers, the railway companies, the city of Manila, and the Bureau of Navigation which has charge of the port and river improvements. Information in regard to the amount of materials used by them has been secured through the coöperation of the officers in charge of the construction. The total production is shown in the following table:

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Value of miscellaneous nonmetallic minerals, in pesos, Philippine currency, 1909.[1]

Products.	1908.	1909.
Stone	149,930	311,177
Gravel	171,360	289,550
Sand	35,000	35,500
Lime	20,000	69,656
Clay products	421,628	422,840
Salt	(a)	375,368
Total	815,918	1,504,091

[a] Not reported.

STONE.

Under this head the production of cut stone, building stone, marble, crushed stone and gravel is discussed.

Cut stone.—The construction of the dam at the headworks of the Manila water supply was continued during the year of 1909, and a small amount of cut stone was used for facing it. This material is a fine-grained limestone which is considerably metamorphosed, so that it approaches a marble. It shows evidence of dynamic action and contains many cemented fracture lines which on weathering develop so conspicuously as to require careful selection of the blocks for structural use. This stone has previously been employed to a limited extent in Manila and may be seen in the General Blanco and Maura bridges, where it was used in the ornamentation of these structures, in the bases of columns in the Santo Domingo Church and in the floor of San Sebastian Church and in a few sidewalks. It has grayish to bluish and yellow tinges and is not very satisfactory as an ornamental stone.

Probably none of the igneous rocks of the Islands were used as cut stone during the year, although a number of them are well suited for the purpose. The andesite from the Sisiman quarry which was employed in the Spanish Bank building has a pleasing gray appearance, and throughout the provinces occasional structures are found in which local stone has been employed. The granite which is seen in sidewalks, pavements of patios, and in the stairways of the older and better buildings of Manila and some towns of the provinces was imported from China.

Building stone.—The water-laid volcanic tuff (commonly called "dhobe" stone throughout the provinces, and in Manila known under the trade name of Guadalupe stone or Meycauayan) is the principal stone which is employed in building. It has a low resistance to compression and the walls of the large public buildings, such as churches and *conventos,* which were constructed of it during the Spanish régime are very thick and have heavy buttresses.

[1] The estimates do not include cost of transportation but are based on the "spot" value of the products.

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At present it is used for filling in the framework of the lower stories of houses and for building outbuildings and stone walls of inclosures. It is so soft when first quarried that it can easily be cut with an ax or bolo, but it hardens slightly on exposure. The ease with which it may be worked is its chief advantage, and the cost of it where water transportation is available is low.

Some coralline limestone and coral from coral reefs has been used in former years in the seacoast towns. It likewise is a soft stone that can be dressed without much labor, but it is no longer employed to any great extent.

Marble.—Samples of the marble which is found at Romblon on Romblon Island have been obtained by the division of mines and polished.

This stone is suitable for ornamental and structural purposes, and certain varieties have a very pleasing appearance. It has been employed to a small extent during the last year in the making of artificial stone, and in former years some attempts have been made to use it in the place of imported marble, which comes principally from Italy. In the San Sebastian Church in Manila there are six fonts made from it, which show its adaptability. It is probable that it would come more into use if proper machinery should be installed for cutting and polishing. It could be employed in connection with concrete construction for plinths, wainscotings, etc., and it would be appropriate and desirable to use this native marble in the public buildings.

Paving stone.—The granite block paving of certain streets in Manila which are subjected to heavy traffic and the granite sidewalks which are common in the city were constructed during the Spanish régime from granite imported from Hongkong.

In some cases the granite sidewalks have been taken up and replaced with cement ones, the slabs obtained from the sidewalk being reëmployed for cross walks and other purposes. At the present time a granite which could be used for paving blocks is not known to occur in the Islands. Such streets of Manila as are paved with stone obtained locally show greater wear than those paved with granite. The andesite blocks which were cut near the present Sisiman quarry may be seen in the pavement around McKinley Square in the Walled City. Although they wear rapidly, they develop an even surface which produces less jolting of the vehicles passing over it than do the granite blocks after they have been much worn. Some paving blocks cut near Angono were also used in Manila. They are characterized by a greenish tinge and an example of a pavement made with them may be seen in front of the Oriente Building. Basaltic paving blocks cut on Talim Island and near Binangonan may also be found in the streets. During the present year no paving blocks have been purchased by the city. Some inquiry has been made for stone to be used in paving the car lines. The rock near Angono appears to be better suited for this purpose than any other material available near Manila. The present practice of the city is to lay wooden-block pavements on the more important streets. Some experiments have been carried on with cement blocks which show that concrete, with a good cement mortar surface in either blocks or slabs, especially when it is given a coat of tar or asphalt, is suitable for paving streets which are subjected to light traffic and where the abrasion by the wheels of vehicles is not directed to definite places by the presence of street-car rails.

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Crushed and broken stone.—The principal use of crushed stone has been for macadamizing roads in the provinces and streets of Manila.

The city of Manila has a well administered quarry and crushing plant on Talim Island. During the calendar year, 59,188 cubic meters of stone were produced at a cost of ₱1.17 per cubic meter, not including transportation.

The Bureau of Public Works operated 16 stone crushers during the year. They were used at various quarries throughout the provinces and produced about 75,000 cubic meters of crushed stone at a cost of approximately ₱2.50 per cubic meter, including quarrying and crushing, but not transportation. This material was used in road and bridge construction.

At Iloilo 2,000 cubic meters of broken stone were used in the construction of improvements of the port by the Bureau of Navigation.

The United States Army engineers have operated a quarry on the mainland south of Carabao Island and a quarry has been opened on Corregidor by the quartermaster's department. At Olongapo a small amount of crushed stone has been produced from a quarry on the naval reservation.

Considerable stone broken by hand has been employed by municipalities and in provincial work, both for concrete construction and surfacing roads.

The Bureau of Public Works has sent to the Bureau of Science samples from 18 quarries to be submitted to the abrasion test in order to determine the suitability of the rock for surfacing roads. The division of mines, of the Bureau of Science, now has a complete equipment of standard machines for testing road material, and during the coming year it is proposed to test the stone received from the various quarries by all the standard methods. Some samples of stone have been submitted to compression tests and in the cement laboratory a number of aggregates of stone, gravel, and sand have been made into concrete blocks and broken to determine their suitability for concrete construction.

Rough stone.—In building the breakwater along the bay front in Ermita at Manila, 43,095 metric tons of stone and rubble from the Sisiman quarry were used.

Perhaps the next most important amount of rough stone produced during the year was secured by the city on the bank of the Pasig near Fort McKinley, where a quarry was opened in the water-laid tuff, the so-called "dhobe" stone, for obtaining material to be used in bringing the streets of Manila up to grade and to furnish at the same time a firm foundation for roadways. From 600 to 700 cubic meters have been produced each month during the last six months for use by the city, and 2,160 cubic meters of this stone were employed by the Bureau of Navigation in making a riprap on the Mariquina River near Pasig.

The cost of production is estimated at 90 centavos per cubic meter, and as the quarry is near Manila this permits of a very considerable saving to the city, since the transportation cost to the banks of the estuaries is low and the stone is more easily secured than at the city quarry on Talim Island and it can be handled more easily than gravel, sand, or earth, which might be substituted as a filling.

At Iloilo 1,320 cubic meters of stone were used as riprap in the improvement of the port.

Important amounts of rough stone have been used throughout the provinces, but there are no established quarries reported, with the exception of Sisiman quarry at the entrance to Manila Bay and a small one opened by the Manila Railway Company near Sucat on the line to

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Batangas. The stone obtained at the latter place is water-laid tuff and has been used in making fills and embankments.

Gravel.—Gravel has been used as ballast by the Manila and Dagupan Railway Company and the Philippine Railway Company, as surfacing for provincial roads, and for concrete construction.

In the Pasig and Mariquina Rivers a deposit of gravel exists which has been obtained by dredging to supply the demand for concrete construction in Manila. One small steam dredge has been operating almost continuously throughout the year and some gravel has been taken out by native workmen who obtained it from the shallow bars by diving and dipping it up in baskets or loading it into bancas direct during low stages of the water.

The Bureau of Public Works used about 325,000 cubic meters of gravel at an average cost of 50 centavos per cubic meter, stripped and screened. This material was obtained locally for the construction of bridges and surfacing of roads and in some cases disadvantageously, because of the scarcity of proper material near the locality where work was in progress. The amount of gravel and crushed stone used each year is greatly increasing. Besides the construction of public buildings, bridges, and other public works requiring these materials, gravel and crushed stone have been employed in building 200 kilometers and maintaining 586 kilometers of first-class and about 1,000 kilometers of second-class roads and trails. During the year, 42 kilometers of new road were ballasted by the Manila Railway Company, 7 kilometers were reconstructed, and, in addition, gravel was required for the maintenance of the entire line.

Sand.—The greatest part of the sand used in Manila has been obtained from the Pasig and Mariquina Rivers by dredging.

The better quality consists of washed gravel screenings which are brought up in dredging for gravel. Sand is also produced by native enterprises and most of it is obtained by divers who bring it up in baskets and load it into bancas. This sand contains a considerable proportion of dirt and is much finer than the washed gravel screenings. A small amount of sand was obtained this year from near Sangley Point near Cavite. The deposit in the Orani River has not come into commercial use. It is situated in the mouth of the river entering the northwest part of Manila Bay and can be obtained without dredging. The United States Army engineers have dredged a large amount of sand from the beaches and shallow waters near the entrance to Manila Bay. This consists largely of comminuted shells. Throughout the provinces sand is obtained locally from the rivers and beaches, the cost being simply that of the work required in excavating and screening. The city of Manila uses from 600 to 700 cubic meters per month at a cost of 98 centavos per cubic meter delivered on the banks of the esteros. It is difficult to obtain an estimate of the actual cost of production, but it should fall far below this price.

Lime.—This has been fully discussed in past reports. There is little new to add at this time.

CLAY PRODUCTS.

Brick.—The brick produced in the Islands is for the most part soft and handmade, but there is some machinery for molding and repressing brick at the kilns near Manila. The introduction of concrete construction has very largely displaced the use of brick in the walls of houses,

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but the demands for brick of good quality is steady and the vitrified article at a reasonable cost would find a ready market as a paving material for streets having light traffic. Throughout the provinces brick is made locally whenever it is needed.

A brick kiln has been operated in the mountain province of Bontoc by the Igorots and the products have been used in the construction of provincial buildings. This enterprise is mentioned because it is a new industry for the mountain people and promises to be important at some localities where lumber is difficult to obtain. In a few cases sun-dried bricks are employed in order to avoid the expense of burning, but these are not suited to the climate of the Philippines. It is reported that the husks of rice are sometimes mixed with the clay in making them. Occasionally bricks are burned under piles of bamboo and straw, but usually a kiln is built. Outside of the down-draft kilns near Manila, there are none which are capable of producing a high temperature and the brick burned in these down-draft kilns is seldom of a good quality because of the economy practiced in the use of fuel. There are numerous places in the Islands where shale beds occur near coal deposits and it is probable that good vitrified brick could be made from the shale and burned cheaply with the slack coal obtained from the mines. Some of the alluvial clay found along the rivers would probably vitrify, and if salt were used, a much harder product could be made than is now turned out.

Tiling.—The ordinary red clay roofing tiles, which are seen on the better class of buildings constructed during Spanish times, are no longer manufactured in large quantities.

Cement roofing tiles reinforced with wires and having proper cleats and gutters to prevent the entrace of the rain and so made that they can be tied in place with wire, are manufactured in Manila and in a few of the provincial towns. Contractors having in charge the construction of large buildings have begun the making of the cement tiles for themselves.

Paving tiles of burned clay are likewise no longer in demand, but are being displaced by cement tiles which are much more satisfactory and can be made in artistic designs and with varied coloring.

The building of the sewers in Manila and in some of the provincial capitals has created a demand for vitrified sewer pipe during the last few years.

The mains in Manila are completed and now small sewer pipe for connections is being imported regularly. The manufacture of sewer pipe could certainly be established in the Islands, and it is an industry which promises to be a successful undertaking if carried on in connection with the making of a good quality of brick and of drain tile. Porous drain tiles for subsurface drainage are not being used, although there is a demand for them.

This is a product which could readily be made in any of the Manila brickyards if machinery were installed, and it is improbable that the industry once started would suffer competition from imported tiles, since the percentage of breakage in loading and unloading from the steamers is very large. To meet the urgent demand for drain tiling, it is proposed to make some by hand molding. This process will no doubt soon be superseded by machinery. Cement pipe and conduit is largely employed and is made locally as demanded, or is purchased from the established factories.

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Pottery.—A very considerable advance in the manufacture of pottery has been made during the last year.

A kiln operated by a Japanese at San Pedro Tunasan, a short distance southeast of Manila, has turned out very creditable glazed work, using common red clay as bodies, and some white clay has been employed in making special pieces. The Bureau of Education has begun a pottery school at Santa Cruz, in Laguna Province, and is contemplating the establishment of another in Manila. The products of these kilns will find a ready sale, since the ware is much more attractive in appearance than that produced by the Chinese, who make some glazed products near Manila, or the native ware which is without glaze.

Common red pottery, which is the principal class used in the provinces, is usually manufactured as a household industry.

The work of making the pots is generally performed by women; the obtaining of the clay and the marketing of the product is done by the men. No pottery wheels are used, but instead a small circular piece of wood is employed as a base on which the pot is molded and can be turned by hand. There are a number of factories on the Pasig River near Manila where wheels are employed, and at these places the large jars for holding water and the native alcoholic liquors are made. In certain of the less important sugar-producing districts, conical receptacles called *pilones* are used in which the crude sugar crystallizes in the form of sugar hats. There is a hole in the bottom of the *pilones* which allows the molasses to drain off into an earthen receptacle which forms the support. The use of *pilones*, however, is diminishing, since the practice of granulating the sugar by stirring it and then sending it to market in bags made from the leaves of the buri palm is gradually increasing.

The introduction of small pottery kilns throughout the Islands and the use of wheels would enable the natives to produce a better ware, especially if they were instructed how to wash the clay and burn it at a high temperature and to produce a salt glaze on the surface which would render the pottery impervious. The practice is to pile the air-dried pottery on the ground and burn it under a cover of straw and bamboo or other easily obtainable fuel.

It is manifestly difficult to obtain statistics concerning the manufacture of the native ware, since in many cases it is made for immediate domestic use. Certain towns favorably situated for water transportation and having clay adapted to pottery making, supply the ware to the principal markets, but the amount manufactured by the families which devote their attention to this industry varies so that only an approximate statement of the production can be obtained.

Clay.—The white clays found at many places throughout the Islands are employed to a considerable extent in the manufacture of a cold water paint. The native name for the clay is *"yeso,"* which is the Spanish word for gypsum, and is a misnomer, since the white clays usually closely approach kaolin in composition.

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In many of the markets the clay can be purchased in the form of balls or cylinders, but those who know of near-by deposits usually obtain the material for themselves at no cost. The total production of clay used for making the native paint probably reaches several hundred tons per annum. The only locality where clay is mined with any degree of regularity is near Los Baños, in Laguna Province. A considerable amount of this product is supplied to the various pottery kilns near Manila, which use it either in making the bodies of ware or in giving a white coat on the outside of the red bodies of water bottles and similar articles. The school at Santa Cruz has found the deposit of clay at Matiquio on the east side of Jalajala Peninsula to be of exceptionally good quality, and will probably use it in the making of the better class of ware. Small amounts of clay having a bluish or reddish color are used for painting and some white clay is employed for making a variety of putty.

CEMENT.

The importations of cement are gradually increasing, reaching a reported value, last year, of ₱1,384,202. A large amount was entered duty free for use by the Insular Government and Army engineers and the railroads. This year the value of the cement imported, according to the prevailing market value in Manila, was ₱1,554,674. It is probable that there will be an increase next year. The Filipino people are learning the value of good cement as a material for construction, and this will tend to stimulate its use in the future. The material and fuel for the manufacture of cement are found in the Islands, and at the present time there is more or less work being done by private enterprise with a hope of finding them all available at a locality which has favorable transportation facilities. There seems to be no good reason why the construction of a cement plant should be delayed longer.

SALT.

This year the production of salt is reported for the first time.

Statistics in regard to it are incomplete, the manufacture of salt being carried on locally. With the exception of a few places which are favorably situated near a proper market, the product is largely a result of individual enterprise and frequently the amount produced is only sufficient to meet the demands of those who engage in the manufacture.

The methods used in salt manufacture are primitive. Generally sea or salt water from marshes is evaporated. Salt springs near Bambang, in Nueva Vizcaya, have been used since very early times as a source of salt by the native inhabitants. Practically all the water from these springs is evaporated. Solar evaporation is the method commonly employed by the Filipinos, but brine is also concentrated by heating it in iron or earthenware vessels. Sometimes wood is soaked in sea water and burned; the ashes are leached with more sea water and the water is finally evaporated. Beach sand containing salt is also leached. Usually some method of filtering is employed. Brine, after it is partially evaporated by the sun, may be passed through wood ashes, rice husks, or sand and gravel, and allowed to flow onto a lime mortar floor, where it is completely evaporated. In a few localities bamboo or bark troughs are used as containers of brine, and the water is allowed to evaporate in the sun. A mountain in Rizal Province called

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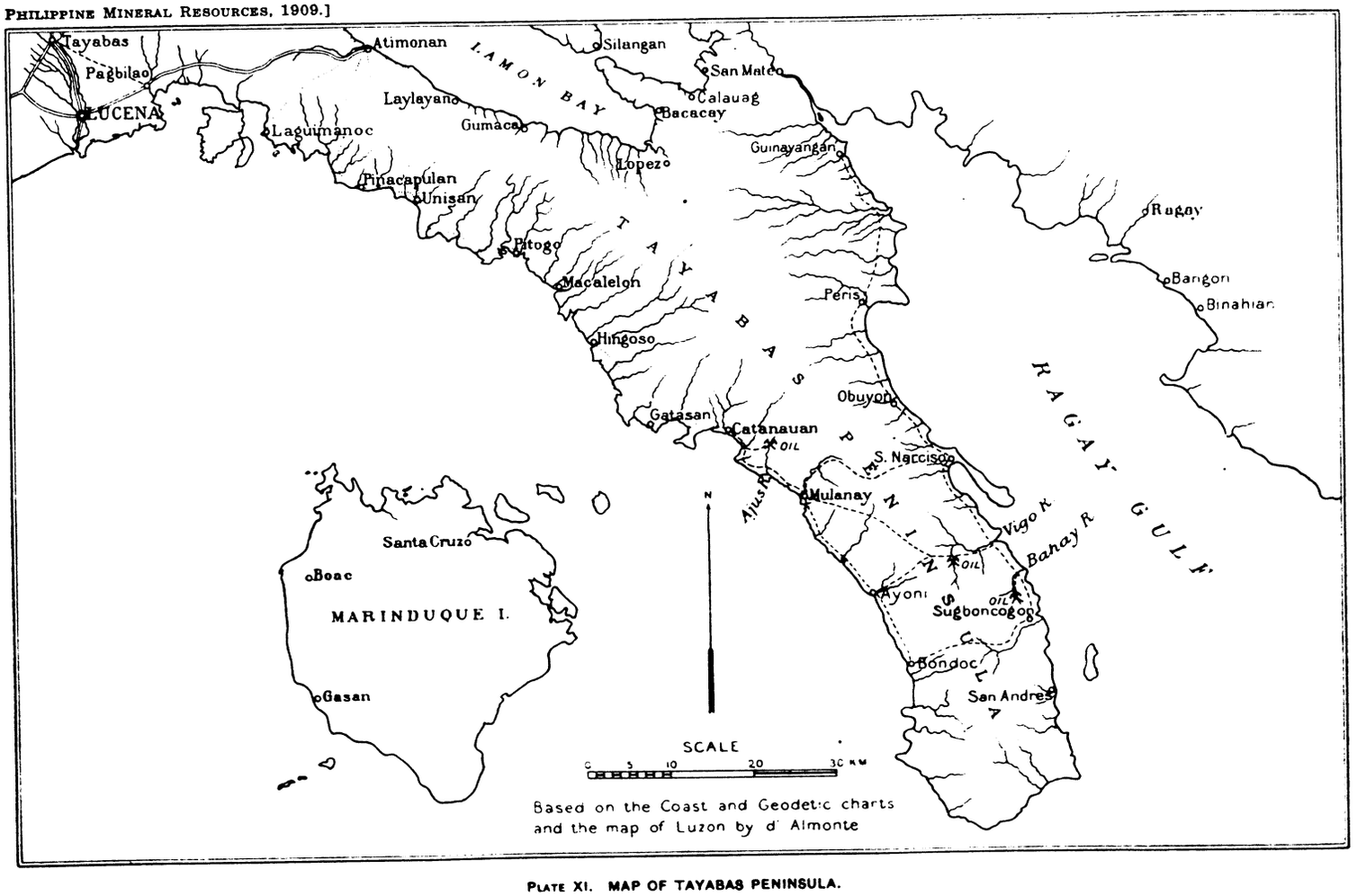

PLATE XI. MAP OF TAYABAS PENINSULA.

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Asin Bato contains a shale impregnated with salt. The Negritos collect the efflorescence and use it. Besides the salt added to food, a considerable quantity is used in drying fish. The amount produced in the Philippines is not sufficient for the inhabitants, as is shown by the fact that ₱116,598 worth of salt was imported during the year. The development of the industry would result in a saving to the Islands and it is probable that the establishment of a small salt-refining plant would be a source of profit, since the native product is coarse and not well suited for table use. In fact, the common method of using the native salt is to dissolve it in water and then pour the salt water on the food. The amount of foreign matter contained in the native product is usually sufficient to give it a discoloration.

OIL AND GAS.

The various occurrences of oil in the Philippines have been frequently reported. With the exception of two wells which were drilled several years ago in Cebu and did not encounter oil in paying quantities, no deep drilling has been carried on. During the last year the Tayabas oil fields have been brought to the attention of the public.

A large number of claims have been staked and one company, the Bahay Oil Company, has begun prospecting with a standard rig and a complete set of tools. The results of their drilling will be watched with great interest and there is reason to think that they will be successful, since the oil showings are good and a shallow prospect hole encountered a fair quantity of oil of superior grade. Other companies expect to prospect their holdings during the year and if the Bahay Company is successful there will be no difficulty in obtaining sufficient capital to thoroughly test the district.

Indications of gas appear with the oil showings. It may be that this resource will be developed incidentally to the prospecting for oil, and if it is found in a commercial quantity gas can readily be employed in some of the manufacturing industries, such as the burning of brick and tile or the making of cement, since the materials for these products are abundant in the oil field.[4]

ARTESIAN AND DEEP-WATER WELLS.

The Bureau of Public Works has been very successful in the drilling of deep wells which furnish a supply of pure water to municipalities that formerly had only shallow dug wells or river water available for drinking purposes.

At the beginning of the year 1909 there were 49 wells completed, 35 of which were drilled with steam and 14 by means of jet rigs. During the year 1909, 20 additional wells were sunk with steam and 75 with jet rigs, the present total being 144. Jet rigs have also been used under provincial management. At the beginning of 1909 there were 8 wells completed by the provinces and at the close of the year the total had reached 133. Most of these are situated in Pampanga and Bulacan Provinces. There are a few in Bohol, Occidental Negros, and Laguna. The United States Army has drilled 16 wells up to the present time, and the Manila Railway Company has completed 4. There are now 10 steam rigs being used in the Islands and the Bureau of Public Works has just received

[4] For the composition of the oil see Richmond, *Phil. Journ. Sci., Sec. A* (1910), 5, 1.

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3 more. The number of jet rigs concerning which records could be found is 31. No doubt there are more, since the construction of these machines is not difficult and they are being made in the provinces according to the patterns introduced by the Bureau of Public Works.

The importance of the water supply from the tubular wells in increasing the health of the localities where they have been introduced is well known, and the amount of sickness is reported to have decreased 25 to 50 per cent in certain localities where the pure water supply is used exclusively. The demand for tubular wells is constantly growing, and it is no longer so difficult to obtain appropriations from municipalities for the expense of drilling. Some disappointment has been experienced in certain municipalities where nonflowing wells were drilled, but the value of a pure supply has appealed to the people and pumping plants are being installed for the wells which are not artesian and in the course of time tanks and distributing systems will probably be added.

Water is a mineral resource, although not commonly regarded as such. The value of it can not be computed in dollars and cents excepting in cases where water is sold. It is doubtful if there is any other mineral resource in the Islands which has been so successfully developed and which is of greater value to the public.

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MISCELLANEOUS NONMETALLIC MINERAL PRODUCTS, PART II.

By WARREN D. SMITH.

Asbestos.—No new occurrences of asbestos have been reported and there has been no further development of the prospect in Ilocos Norte..

Glass sand.—A good glass sand was recently discovered during the prospecting of placer ground in the Paracale mining district of Ambos Camarines. The boring machine penetrated a bed of quartz sand 12 feet thick. The grains were very clear and rounded and the deposit was quite free from other mineral fragments.

Graphite.—Graphite clay occurs in Ambos Camarines.

Mica and talc.—Both of these minerals are found in fair quantities near Pasuquin, Ilocos Norte. No large sheets of mica, however, have been encountered. The promising areas where these minerals may be looked for in commercial quantities are those wherein granite has been noted, for instance, in Ilocos Norte, Nueva Vizcaya, and Ambos Camarines.

Mineral waters.—A fairly complete list of mineral water springs has been published in our two last bulletins. The two most prominent ones are at Los Baños, in Laguna Province, and Sibul Springs, in Bulacan; at the former 400,000 liters were bottled in 1909, at the latter 1,000.

Abrasives.—*Sandstone* is found in all parts of the Islands and is used by the natives for sharpening their *bolos*.

Tripoli has been encountered on the naval reservation at Olongapo, but no production is recorded. Without any further preparation it makes an excellent polish for metals.

Novaculites. In several parts of the Islands, notably Cebu, an exceedingly fine-grained rock much resembling a novaculite is used as a whetstone and serves very well. There is likewise no production of this stone.

Ochers.—The red oxide of iron in the form of earth is to be found everywhere in the Philippines. In some places it is fine enough to be used as a pigment. Excellent grades of red and yellow ocher occur in Ilocos Norte and these have been exploited to a limited extent.

Gypsum.—No new occurrences of gypsum have been reported during the past year.

Pyrites.—Pyrites occurs abundantly in the igneous rocks and occasionally fair-sized segregations of the mineral have been reported. As the present demand for sulphuric acid is small in the Philippines, there is probably little to be made out of its exploitation. The chief interest in pyrites here lies in the fact that much of the gold values are found in conjunction with this mineral.

Sulphur.—Sulphur is known to occur in appreciable quantities on Mount Apó in Mindanao and on the Islands of Leyte, Biliran, Camiguin de Mindanao, and Camiguin, one of the group north of Luzon. The last named seems to be one of the most promising localities.

It is quite possible that during the course of artesian-well drilling buried deposits of sulphur may be encountered. The largest sulphur deposit in the world was accidentally discovered during the process of drilling a well in Louisiana.

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GEOLOGY OF THE PHILIPPINE ISLANDS.

By WARREN D. SMITH.

The map on Plate XII is only very general and is reproduced as much for the purpose of showing how much remains to be done, as to indicate what has already been accomplished. Obviously, no comprehensive work on a large scale can be attempted until we have better maps of the public domain. Except along the coast line and in smaller areas like the mining districts, where some triangulation has been accomplished, we have no accurate control on which to base such work.

We now quite thoroughly understand the geology of the vicinity of Manila, the Islands of Panay, Cebu, Masbate and the three mining districts of Benguet, Masbate, and Ambos Camarines. We have a fair general knowledge of north-central Luzon, Leyte, Mindanao, and the Sulu Archipelago.

On this map we have attempted to delimit the following formations:

Alluvial; tuffs, sands, and agglomerates; Tertiary sedimentaries, extrusives; metamorphic rocks and the cordilleran complex of igneous rocks. We have not yet found any rocks which are certainly older than the Eocene.

Table I gives a provisional tabulation of the stratigraphy of the Philippines and some attempt at correlation.[1]

TABLE I.—*Provisional table of Philippine stratigraphy.*

Period.	Formation.	Type locality.	Distribution.	Economic deposit.	Characteristic fossil.
Recent	Piedmont deposits, including fluviatile.	Cagayan, Mindanao.	Throughout the Archipelago.	Bench placers.	
	Solfataras	Laguna Province.		Kaolin and sulphur.	
	Talus		Throughout the Archipelago.		
	Spring deposits	Mountain Province.		Gold, building sand.	

[1] For fuller discussion readers are referred to a forthcoming article on the Geology of the Philippines, by W. D. Smith, to be published in the *Philippine Journal of Science* and in *Regionale Geologie*, Vol. VI, edited by Doctor Steinmann, in Bonn, Germany.

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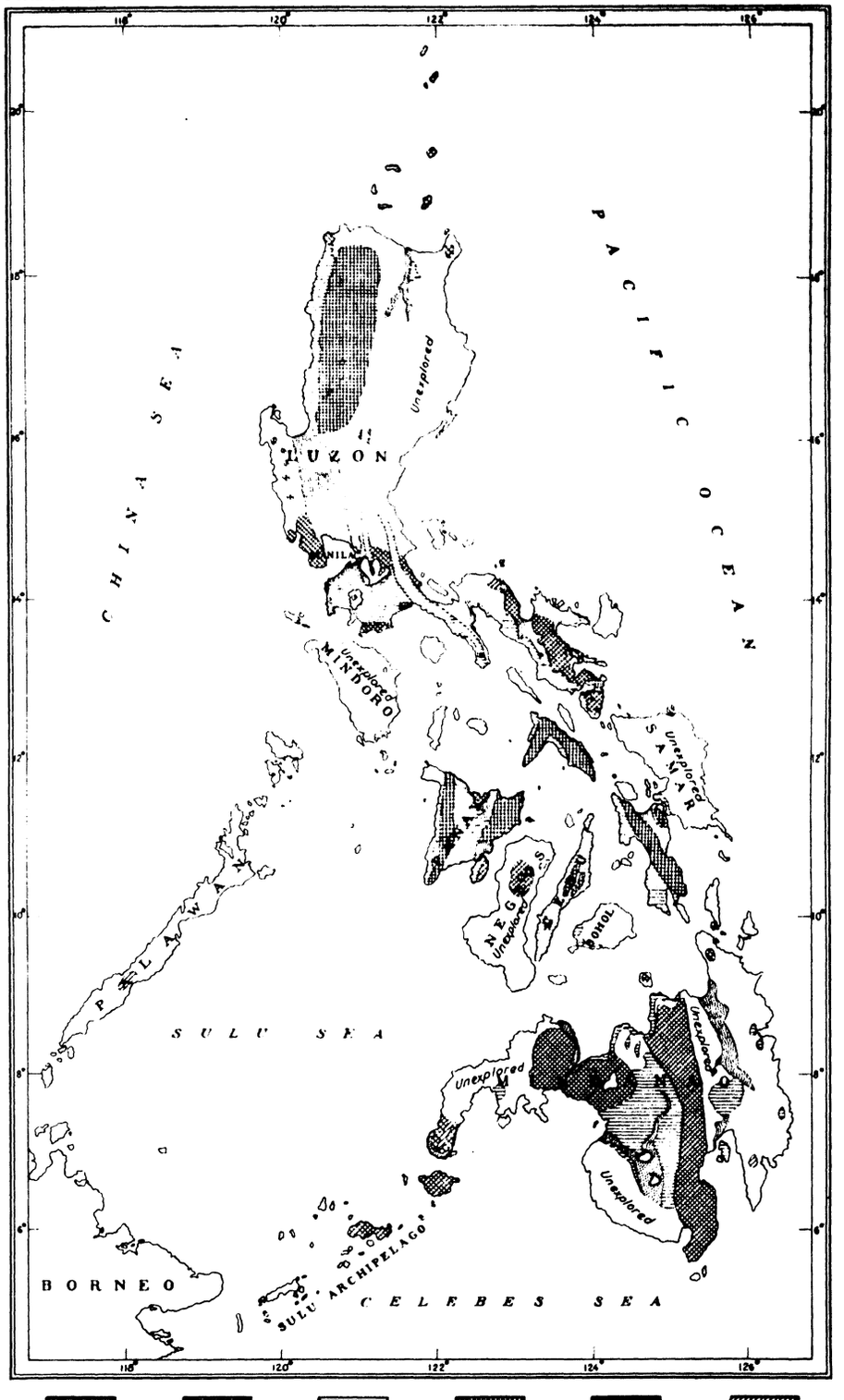

PLATE XII. GEOLOGICAL MAP OF THE PHILIPPINES.

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Period.	Formation.	Type locality.	Distribution.	Economic deposit.	Characteristic fossil.
Recent	Coral reefs	Cebu	Along much of the Philippine coast line.	Building stone and lime.	
	Littoral deposits.	Sangley Point		Sand	
	Volcanic tuff	Vicinity of Manila.	Southern Luzon, Ilocos Norte.	"Guadalupe" stone for building.	Leaves, probably belong to *Euphorbiaceæ*.
	Basalt and andesite flows.	Mount Arayat and Mount Apo.			
Unconformity.					
Pleistocene and Pliocene.	Raised coral reefs.	Cebu, west coast.	Cebu, N. W. Luzon.		
	Marls	Ilocos Norte	Samar, Agusan River.		*Hindsia dijki* Mart.
	Eruptives	Mount Mariveles.	Mindanao, Luzon, etc.		
Unconformity.					
Miocene	Limestone—upper.	Cebu		Burned for lime, very pure.	Shells very similar to recent forms; chiefly coral reefs.
Unconformity.	Andesite flows	Cebu	Cebu, Masbate, etc.	Gold, silver, manganese, lead.	
Miocene	Limestone—middle.	Cebu	Cebu, central Luzon, S. W. Luzon, north Mindanao, east Mindanao, Romblon.	Romblon marble, Montalbon limestone.	*Lepidocyclina insulae-natalis* Chap.; *Lithothamnium ramosissimum* Reuss.
	Sandstone	Batan Island		Oil in Tayabas and Cebu.	*Cyclaclypeus communis; Orbitolites*, etc.
	Shale	Batan Island		Coal deposits, Cebu, Batan, Polillo, Masbate, Mindanao, Luzon, etc.	*Arcas, Callianassa dijki* Mart.; *Vicarya callosa* Jenk.
Oligocene	Limestone—lower.	Cebu, Batan Island.			*Nummulites niasi* Verb.
Age uncertain, probably Tertiary.	Crystalline schists, granite, gneisses.	Camarines	Camarines, Ilocos Norte, Cebu, Zamboanga Peninsula, Romblon Island.	Gold, mica, talc, apatite, hematite, magnetite.	
	Iron formation.	Bulacan			
Unconformity (?).					
Pre-Tertiary	Quartz porphyry.	Lepanto	Central and northern Luzon.	Copper ores	
	Diorites	Benguet	Northern Luzon, Leyte, Panay.	Gold, tellurium, silver.	
	Gabbros	Leyte	Leyte, Mindanao, etc.		
	Pyroxenite	Ilocos Norte	Ilocos Norte, Zambales Mountains, Batan Island.	Serpentine and asbestos.	
	Peridotite	Near Olongapo			

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The geologic history of the Philippines briefly has been as follows:

Upon a foundation of a complex of igneous rocks, the age of which we do not know conclusively and which marked the high points along one or more submerged ridges at the crumpled edge of the great land horst of Asia, Tertiary sediments were laid down. These consist of conglomerates, basal and otherwise, sandstones, shales containing sub-bituminous coal seams; limestones, etc. Above these and unconformable are flows of various classes of volcanic rocks.

At the close of the Miocene a general upheaval and folding occurred throwing the strata already laid down into anticlines and synclines. The anticlines are generally marked by the present islands and the synclines by the straits. Consequent upon this general disturbance there ensued a period of ore deposition.

After the Miocene disturbance, which was a part of a great upheaval over large areas of the globe, occurring particularly through southern Asia and Malaya, there was a subsidence, at least in some parts of the Archipelago, and the Pliocene and Pleistocene coral limestones were formed. Later another period of elevation ensued, as is demonstrated by raised beaches, deltas and terraces, but certain parts show very recent depression.

Although the age of the crystalline schists is more or less uncertain, it seems very probable that for the most part they are simply metamorphosed Tertiary sediments and late volcanics. There is absolutely no evidence at hand that they are Paleozoic. All the fossils so far found are Tertiary.

One of the last and most important episodes in the geological history of the Islands was the building up of the great tuff deposit in the Central Plain of Luzon, particularly near Manila. This is hundreds of square miles in extent and many feet thick. It has played no little part in changing the configuration of the land, for before its deposition this area was at one time covered by the sea and that portion of Luzon comprised in the Provinces of Bataan and Zambales was entirely separated from the rest of the island.

The deposition in many parts of the rich gold-bearing sands and gravels is a later chapter in the history of the Islands and one that is far more important to us.

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CYANIDING IN THE PHILIPPINES.

By C. M. Eye, E. M.

(Formerly Superintendent of the Benguet Consolidated Mining Company, now of the Colorado Mining Company.)

Thus far, the application of the cyanide process to the ores of the Philippines has been at two properties at Antamok, in the Benguet district, but from what is known regarding the character of the ores in other parts of the Islands and of the district mentioned, the use of this method of treatment probably will become much more general. It is with a view of assisting in this wide application that the plants on the properties mentioned are herein described and the general results and conclusions deduced from their operations given in considerable detail.

The first cyanide plant erected in the Islands at the mines of the Benguet Consolidated Mining Company at Antamok, Benguet district, was put into operation toward the close of 1906 to treat the tailings from the stamp mill, after amalgamation. The original installation consisted of four leaching tanks each 22 feet in diameter by 5 feet in depth, each with a central bottom discharge door 16 inches square; two solution storage tanks each 12 feet in diameter by 8 feet in depth; two gold solution tanks of the same dimensions as the solution storage tanks; two sump tanks each 14 feet in diameter by 6 feet in depth; one 1½-inch centrifugal pump; one set of forty individual bucket extractors or zinc boxes, arranged in four rows of ten in each row; one Hampton zinc lathe; one emery wheel; one small vacuum pump and one small vacuum filtering tank, the whole constituting a regulation leaching plant of the simplest type. The leachers were of 3-inch and the other tanks of 2-inch Oregon pine lumber with flat steel hoops throughout. The filters in the leachers consisted of a grating of pine strips 2 inches high, on which was placed, in two of the leachers, a layer of coco matting, over which was stretched a sewed burlap filter cloth. In the two other leachers, a layer of burlap was first nailed down and then a layer of raw coco fiber was laid, over which was stretched the regulation burlap filter cloth. For a time the raw coco fiber served as well as the coco matting, but it soon packed too hard, and later was removed entirely and the filter worked with but two layers of burlap, the top one consisting of the heaviest "Calcutta" bagging obtainable in this market.

Recently the leaching was improved by raising the filters to about 4 inches from the bottom, and fitting them throughout with coco matting, which seems to be the very best filtering medium obtainable.

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The individual zinc boxes proved insufficient and troublesome, and therefore they were soon replaced by regular redwood extractors of two double lines of compartments of nine compartments each, the dimensions of each compartment being 24 inches by 30 inches by 30 inches deep, with bottom plugs for removing the product at clean-up. An additional leaching tank of same dimensions as those in use was added in 1908. Two more solution storage tanks each 7 feet in diameter by 7 feet deep were added last year, and since then one of these has been converted into a mixing tank for lime, the solution being pumped through it on the way to the leachers.

The extreme acidity of the ore has always required the addition of considerable alkali to protect the cyanide from decomposition. At the start, the common method was tried of adding quicklime with the ore as fed to the batteries, but this was soon abandoned, as it took a prohibitive amount of lime to accomplish the neutralization of all the acid, and also because a heavy deposit of calcium sulphate (artificial gypsum) formed on the screens, mortar lips, etc., and even incrusted the amalgam coating on the table. Then the method of spreading a layer of lime on the top of the leacher charge was tried, but an insufficient amount of lime was dissolved and carried downward to keep the charge neutral, even when it was given a preliminary water wash with the lime on top. Lime at that time was costing 2 cents gold per pound delivered, and, as caustic soda could be delivered for 5.5 cents gold per pound, the use of lime was for the time abandoned, and soda employed instead.

The practice then developed of draining off the water from a charge when filled, leveling off the top, putting about 50 pounds of caustic soda in a bucket in the center of the top and running water through it until the charge was covered, then opening the drain below and allowing this soda wash to drain off to waste. Then the drain was closed, a solution of full working strength (35 per cent KCN and 2 per cent soda) put on from the bottom until the charge was well covered, the charge then allowed to stand for a few hours, then percolation started downward, and continued under full head for from six to seven days, then the solution drawn down fairly close to bottom and weak solution put on, this following in successive heads for several days, then several successive heads of wash water were put on, and finally the charge sluiced out to waste.

The whole of the treatment took about eighteen days, which is an unusually long time, but it seemed to be necessary, as only a long contact with a strong solution would give a fair commercial extraction. This prolonged treatment was largely responsible for the rather high consumption of cyanide, which averaged a little over 2 pounds per ton treated. The use of soda was not entirely satisfactory, for the reason that unless very great care was taken to add it so that the degree of alkalinity of the solution coming off was nearly constant, there would be a formation of hydrates of iron and alumina, etc., which would clog the filter, get into the zinc boxes and make trouble generally. These were only soluble in a considerable excess of caustic soda in the solution. On the other hand, if the strength of soda was very much higher than the figure given, it

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led to an excessive consumption of zinc shavings. With the lowering of the price of lime to 1.25 cents gold per pound and the introduction of a mixing tank as noted elsewhere, the use of lime was resumed and of caustic soda abandoned, except to help out the lime in case a solution was acid or neutral. No more trouble was experienced with hydrates after lime was substituted for soda. No trouble of moment was ever encountered in securing good precipitations in the zinc boxes when they were properly dressed and filled, and the hydrates kept out, even though there was at all times an appreciable precipitation of copper on the zinc.

Soon after the beginning of operations it developed that the slimes, which were separated from the sands by an upward current classifier and run to waste, were of sufficient value to pay to treat, so a slimes plant, consisting of two tanks, each 14 feet in diameter by 16 feet in depth, was added. Each of these was provided with an overflow launder around the top, and with a stirring mechanism within, driven by bevel gear from a shaft above, common to both agitators. The stirring gears were designed by me and made in Manila, and consisted of a 3½-inch vertical shaft, to the upper end of which was keyed half a standard coupling, reversed, and to the lower end, the other half of a coupling in its normal position. The shaft was carried above by a train of balls in a groove in a cast plate, the under side of the coupling bearing on the balls. If it were desired to raise the whole mechanism, the supporting plate was raised by a chain block attached above to a basket frame fastened to the bearing plate. The rig could thus be raised or lowered while the agitator was running. The shaft was kept in line by two vertical guide bearings and when being raised or lowered slipped through the bevel gear by virtue of the latter being connected to it only by a feather in a long keyway. The agitator rig at the bottom consisted of four radial arms of 3-inch pipe bolted and clamped to a plate of three-fourths inch steel, 2 feet square, which was bolted up under the half coupling. On each radial arm 10 socket castings were clamped at equal spaces of 9 inches, and in each socket was fitted a stick 6 feet long and 1¾ inches square, set vertically. The speed of the agitator was 16 revolutions per minute and the agitator was all that could be desired. These tanks had square discharge doors at the side at the bottom, and were provided with an entering launder that terminated in a square box reaching several feet below the surface near the center.

In practice, the stream of slimes from the classifier was run into the tank, being charged through this box, the solid matter settling to the bottom and the clear water overflowing the side to waste. As soon as the charge of settled slimes had reached a depth of about 7½ feet, the stream was switched to the other tank, and the supernatent water removed from the settled charge. Then about 500 pounds of slaked lime was added, agitation started, cyanide solution pumped in, the necessary amount of cyanide added to bring it up to working strength (testing 1 per cent KCN) and agitation continued for nine hours. This accomplished very thoroughly the dissolving of the gold values. After the agitator has been stopped and raised, the slimes were allowed to settle to their level in the tank, the clear gold bearing solution being removed by decantation through a hinged pipe in the side, and conducted to the weak gold tank in advance of the extractors. (The weak-solution circuit for the leaching was used for the treatment solution for the agitation.) One complete settling, decantation and settling consumed eighteen hours. Successive charges of weak solution were pumped on, agitated for fifteen minutes each time and removed by decantation, as many such charges

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being used as the time permitted before the tank was needed for the next charge. Usually 6 or 7 such decantations were made. This method of removal of the values was slow and incomplete. However, owing to the fact that at the maximum degree of settling the ratio of pulp to solution was still 40 to 60, or 1 part of solid matter to 1½ of liquid. In order to gain additional capacity as well as more complete washing, an automatic filter plant consisting of Ridgway one-unit filter, a double cylinder Imperial compressor, a horizontal wet displacement pump, and a steel-lined slimes pump was installed during the past summer. This plant was driven by a separate water wheel, and made a very complete installation in itself, but, unfortunately, it was lost in the flood that destroyed the greater part of the cyanide equipment in November of the present year, and before very many data as to its efficiency were obtained. However, it would undoubtedly have effected a very material saving, as well as have increased the capacity of the slimes plant several times over.

At the beginning of operations, the crushing was rather coarse, a diagonal slot screen with width of opening corresponding to 10 mesh per linear inch being used. However, leaching results showed that this was too coarse for good work, and the mesh was gradually increased, first by using 16, then 20, then 24, and finally 30 mesh sizes, with increasingly good results. Investigation of the sands before and after leaching also showed that a small amount of high-grade iron sulphide carried a fair percentage of the values, and that this sulphide still contained good values after leaching, so a Wilfley table was installed over which the sands passed from the classifier, and from one-thirtieth to one-fiftieth of the tonnage was removed as a high-grade concentrate which was stored for future treatment or shipping. A series of experiments on this material showed that by fine grinding in cyanide solution in a tube mill, well over 90 per cent of the value was dissolved. In fact, all of the work done at this plant showed that when the ore is reduced to slime, the solution of the gold content can be accomplished easily, which points to this method of treatment as best for the whole tailings from the stamp mill, provided that every part of the latter will stand the cost of the reduction to slimes, which would not be large, in view of the splendid and cheap water power available. It is to be hoped that when the plant is renewed, it will be along these lines.

The plant of the Bua Mining Company, similar in many respects to the original leaching plant of the Benguet Consolidated Company, was installed and put into operation in 1907 to treat the tailings from stamps after amalgamation. The principal point of difference is that it had six leachers of 50 tons capacity, where the Consolidated mill originally had four of 60 tons capacity. The character of the ore treated in the Bua mill is entirely different from that of the Consolidated, for, while the former is quartz and iron pyrites, with strong acid reaction and high values in slimes after crushing, the latter is chiefly calcite and rhodochrosite with more or less black oxide of manganese, the whole having a distinctly alkaline reaction, and giving a slime, on crushing, of low value. The treatment has therefore been simpler, and the results generally better on this ore.

The chief improvement which has been worked out on the Bua treatment since its inception has been the practice of turning the charge over by hand after the water has been drained off and before the solution has been put on. This is done by beginning near one edge of the tank and shoveling back a crescent

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shaped section and then with opening to start with, turning over the material clear across the tank. With cheap labor, the cost is slight, four Igorots at 25 cents gold turning over a 50-ton charge in a day. It is claimed that it increases the extraction by several per cent, and shortens the period of treatment by two or three days.

The Bua product has always been high grade and clean, owing to the absence of copper in the ore and a solution fairly free from foreign salts. While actual operations on a commercial scale have been limited to the two properties mentioned, yet extensive tests on lots of ores from several properties in Masbate have invariably given high extraction results by fine grinding, agitation and filtration, but poor results from leaching. The all-sliming method would seem to have a wider application than leaching in all the districts where cyaniding is applicable at all; in the one case where leaching has given good results, it is an open question whether, with cheap water power available, fine grinding would not give returns sufficiently better to more than pay for the difference in cost.

Cyaniding will probably not successfully be applied to the ores of the Paracale district, because these as a rule contain considerable amount of base minerals, and the gold is coarse, both of which conditions are against cyaniding. However, it is probable that further deposits of ore in which the gold is finely divided will be found in the Islands, and if such deposits are free from copper and other deleterious substances, and are fairly large, so as to assure a good tonnage, they will not need to be high grade in order to be worked at a profit by the cyanide process in its present highly developed state.

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REPORT ON THE AURIFEROUS DEPOSITS OF THE SECOND DISTRICT OF THE DEPARTMENT OF MINDANAO, MISAMIS.[1]

(Excerpt.)

By ENRIQUE ABELLA Y CASARIEGO.[2]

SITUATION AND LIMITS OF THE AURIFEROUS ZONES.

The auriferous zone known in Misamis is comprised within the territory which surrounds the Bay of Iligan on the west, bounded by the Cutman River on the east, and on the south by limits depending upon the distance one can penetrate, a limit which at Iligan is the coast itself, in which place nothing noteworthy can be studied with regard to minerals (fig. 2). Within this space the important

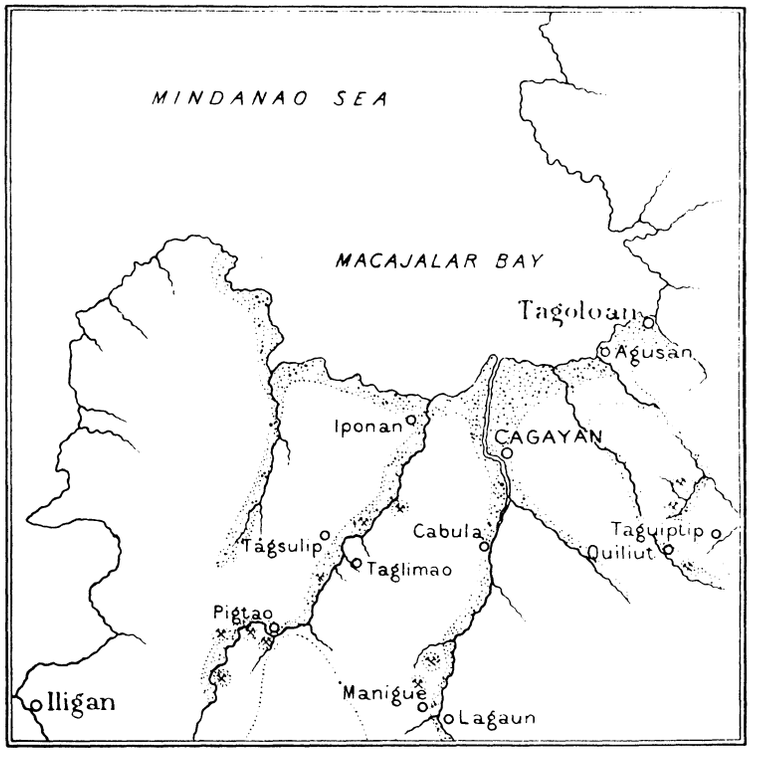

FIG. 2. PLACER DEPOSITS IN MISAMIS.

[1] Translated by Warren D. Smith from the Spanish report as published in 1877 in Vol. VI of the Boletin de la Comision del Mapa Geológico de España.

[2] Former chief of the Cuerpo de Ingenieros de Minas under the Spanish Government in the Philippines.

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localities are along the courses of the Bucalalan, Iponan, Cagayan, Bigaan, and Cutman Rivers, all of which empty into the sea, although with different volumes of water, also possessing very different gold values. The most important of these is the Iponan River.

GENERAL FEATURES OF THE WORKINGS ALONG THE IPONAN RIVER.

1. SANDS.

Composition and character of the bed of the river.—The source, in fact the greater part of the course, of this river is not easy to visit because it lies in the territory occupied by the Mohammedan natives (Moros) and can be followed for only 7 or 8 leagues from its mouth. In these 7 or 8 leagues with which we are acquainted, the supply of water and the richness of the stream deposits scarcely diminish, so that we can presume that along the upper waters, even well into the interior, extensive areas exist. The river descends from the southern limits of the known tract engorged between marl and limestone hills, of which I shall treat in the second part, some of which cause the river to describe sharp curves in its course. Because of these circumstances the gradient of the stream is not entirely uniform, there being rapids at many points, followed by quiet stretches constituting ponds of greater or less depth. When the stream reaches the village of San Simon, its banks widen, become lower, and the river runs to the sea in an open valley with a gentle gradient. Its bed before reaching this last point is gravelly and sandy, hence the waters are quite transparent, though the material on the bottom is moving. The pebbles and sand which it contains at times are of considerable volume. Mineralogically considered they are quartz (petrosilex), and especially fragments of trachytic rocks of various colors and porphyry.

In this gravel one finds flakes and dust of gold, more or less fine, sometimes in flakes of considerable size not deposited uniformly over the bed of the stream, but in certain spots, quite numerous to be sure, where the conditions have been favorable for the precipitation of heavy bodies, as in the sudden changing of the course of gradient of the stream. It is a matter of observation also as it is natural to expect that the particles of gold are of smaller size and more scattered as the mouth of the river is approached, so that between San Simon and the sea not enough can be recovered to pay for the labor of the washing.

2. BENCH PLACERS (ALLUVIONS).

Not all the gold is won from the sands of the river bottom, and they have recourse to them, as I have already indicated, only in the dry season, during which the bench placers within the limits of the hydro-geologic basin of the Iponan River can not be worked.

Situation.—From the village of San Simon, where the valley walls are higher and more confined by rounded hills, the river receives as one goes upstream a great number of tributaries which cross many alluvial and auriferous spots and also unimportant arroyos. For example, following the river upward, there is, on the left, the small valley of Pasayanan, with indications of scattered and ancient workings, then, on the right, the richest, that of Batinay, which moreover is of greater extent; then that of Dominalog with recent workings of a less primitive character; and continuing, those of Babantohon, Pigsagan, Dumalogdog, and the famous Pigtao, the locality where the most remote Christian settlement, now withdrawn to Tagsulip, was established, and finally, Camingañan, Cayomangon, Saganahai, Tapbagbag, and Taculut, almost within the territory of the Moros.

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Continuity.—The placers are not all situated on the same level as the waters of the Iponan River, but at a certain altitude above them, not exceeding as a rule 20 meters, and in elevated parts of the lateral branches, though never very far from the principal river, demonstrating that the origin of the placers bears a definite relation to the ancient bed of the stream. This bed, formerly very much wider than the present one, has suffered with time from the effects of partial denundation which has eroded the once continuous capping of the alluvions, resulting in the present discontinuity and isolation of these localities.

Variation in size of the particles of gold.—As one goes southward toward the upper part of the river, he finds as a rule richer placers, in which the particles of gold become larger and can be found in nuggets weighing as much, sometimes, as 1 or 2 *taclas* (tacla=37.68 mg.). It is thought for this reason that the placers situated within the territory of the Moros must become much richer, and, in fact, I had occasion to see a certain quantity of gold which had come from there, which in great part consisted of flakes, rather than of grains and dust, as much as 2 millimeters in width and more than 5 millimeters in thickness.

General character of the placers (alluvions).—The general character of the alluvions is quite uniform. Essentially argillaceous throughout, it is in the upper part composed of a very sticky clay, reddish and containing very small rounded pebbles, fragments of old slates of various classes, which become more numerous and larger as one goes deeper, the clay which envelops them being usually whiter, more sandy and not so compact and containing pebbles (cantos) of eruptive rocks, others of magnetic iron or hematite, which the natives call *tonasé*. The abundance and size of these pebbles are considered a sure indication of the richness of the placer. The gold is not confined exclusively to the portion in which the pebbles are found, since in the uppermost layer of the alluvion gold dust begins to be encountered although quite scattered; but notwithstanding this dispersion of the gold, most of the metal, the greater richness, is always found near the bed rock. The depth of one of these placers never exceeds 7 meters in those places where it has its greatest area, nor does it become less than a meter in the smaller areas, this difference being due to the subsequent denudation to which I have alluded above. In those spots where this process has had little effect and where the alluvions are quite intact, the natives distinguish in them various horizons which really correspond to the changes of composition and appearance I have already pointed out, and distinction and classification of which reveal a very exact knowledge of the structure of placers, remarkable in a race so primitive and backward. This classification from above downward is as follows:

Payason.—Clay, more or less dark, which lies immediately below the vegetation.

Acaron.—Red clay, very sticky, with small pebbles, generally slaty and semi-decomposed (*bató patay*=dead rock, literally).

Dugcálon.—Yellow clay, more sandy, less sticky, with pebbles of quartz and eruptive rocks, some of great size, others smaller of hematite or magnetite (*tonasi*) with the maximum richness of gold.

Dapanás.—The bed rock is marl, limestone, or conglomerate.

However, these divisions are not all present in the placers, since there are spots, as I have indicated above, where the eroding action of the water has removed some of the upper layers, leaving parts of those below, and because of its richness the natives work the ground with profit in spite of the small thickness.

As for the distribution of values in the placers in the same horizon, that is to say within the zone of richness, *dugcálon*, it is not uniform nor can it be, if one recalls the circumstances attending its formation.

Those places in which particularly rich values were encountered are called by

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the natives, the *Montcses*, as well as the Visayas, *topadas*, a good Spanish word, and this seems to indicate that Spaniards, probably coming from Mexico, may have once worked these placers.

Method employed in the district for the recovery of the gold.—The method is in reality the same as that employed by the natives throughout the Islands for working the placers, and though quite simple it is very similar to that used even to this day in other countries, and reveals a certain knowledge of the rudimentary principles of mechanics which seems to corroborate the hypothesis of former Spanish work.

To summarize, this proceeding has four phases distinct as to order and object. (1) *Investigation* of the deposit by means of *tujubs*, not always necessary, as, for example, when by other indications or by known signs they know beforehand that the placer is rich in the part they expect to work. (2) *Preparation* for the work by the construction of a canal, reservoir and all the other work. (3) *Concentration* of the alluvial ground or the exploitation proper of the deposit, by means of the work in the *banlasan*. (4) *The cleaning up (depuracion)* of the sands by hand washing with the *bilingan*, finally obtaining the gold free. Each one of these phases represents quite different amounts of work; the first, as I have just indicated, is sometimes dispensed with; the second of all, undoubtedly, is the most laborious; the third, it can almost be said, works of itself, and the fourth, though quite tedious, has to do with small amounts of material and constitutes only a very small fraction of the work.

DESCRIPTION OF EACH OF THE MORE IMPORTANT PLACERS.

1. VALLEY OF THE IPONAN RIVER.

The placer of Pasayanan. Ascending the river from San Simon the first placer encountered is situated in the Valley of Pasayánan. It is small and of little importance. Quite flat at its entrance, the valley continues to rise toward the south, dividing into two arroyos, approximately a kilometer and a half from its mouth. Near the fork, on the left, some hills rise up to the general level of that part of the country and part way up the sides of these, not far above the valley floor, there are some remains of placer workings not very recent and important. The alluvial material situated here is of scant importance, from 1 to 1.5 meters, quite argillaceous, with small bowlders, but none of hematite or magnetic iron, which in the other placers serve as indicators of rich values.

Placer of Batinay.—Following the river upward one comes to the Valley of Batinay which is of greater extension than the former, but with few remains of workings. Its alluvial matter is moreover argillaceous, but with more pebbles and more characteristic ones than those in the Pasayánan, the placer being situated in the upper part of the bottom of the valley, before the road between Iponan and Tagsulip is reached.

Placer of Dominolog.—Upstream from this is the very important placer of Dominolog or Pinatagan, the names being derived from an arroyo and a creek near by. A great backward swing of the Iponan River forms a kind of peninsula in which the placers are located. At a great number of points on this there are little pits (pozitos) or *tujubs*, some completely demolished, and a large and recent *banlasan*, with its reservoir, canals and aqueduct for making a depression in the formation. At a certain distance from the *banlasan* a true mine shaft quite different from the *tujubs* of the country had just been opened. This was

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rectangular in section and perfectly timbered with planks and wooden pins of sufficient resistance to prevent the washing away of the alluvion which is here very argillaceous. It had a depth of 7.5 meters and a sump (caldera) 0.25 meter to 0.30 meter for collecting the water, which was quite abundant. To the northeast of this sump a small gallery had been started in the *dugcálon* or pay streak. At the mouth of the shaft a windlass with a hemp cable, *tanayas*, or baskets for removing the dirt and buckets of tinned sheet iron for taking out the water had been installed. The excavated material was run off by means of a wooden flume to a storage tank where there was a cradle for washing.

This pit afforded me an opportunity to study the alluvion which at this place was complete in all its zones. The section was as follows:

1. 0.25 meter Soil.
2. 0.50 meter *Payason* or brown clay.
3. 4 meters *Acaron* or red sticky clay.
4. 2.50 meters *Dugcálon* or pay streak.

In the recent *Banlásan* situated some 200 meters to the south of the pit, the ground presented the following section:

1. 0.20 meter Soil.
2. 0.30 meter *Payason* or brown clay.
3. 3 meters *Acaron* or red clay.
4. 3 meters *Dugcálon* or pay streak.

In these 3 meters of the *dugcálon* there were seen many bowlders as much as a half a cubic meter in volume, and in the lower part are innumerable rounded pebbles of *tonase*, or magnetite and hematite. The alluvion, then, in this locality had all the characters of richness by which they distinguish the *topadas*. In the shaft the *dugcálon* had neither such large bowlders nor so great a quantity of oxide of iron and the clay was white and more sticky. The place which has been opened up should be less rich than the *banlásan*, in spite of the fact that no great distance separated them.

Placer of Bantohon and Pigsagan.—Continuing up the river, after leaving Dominolog we come to the Valley of Bantohon and Pigsagan, the placers of which show nothing in particular, their general features being very similar to those of the first. There are numerous remains of *tujubs* and *banlasan* which have the appearance of having produced a fair showing of gold when they were worked.

Placer of Pigtao.—This locality, situated on the site of the once prosperous gold mining pueblo of Pigtao, also forms a kind of peninsula between the Iponan and Pigtao Rivers and elevated above the former approximately 20 to 25 meters. Almost the whole peninsula is made up of auriferous placer ground, which has not been exploited because of the site of the pueblo and scattered arrangement of the houses. There are, nevertheless, some old *banlásan* near the Iponan River, and others, more recent, on the trail from the pueblo to the Pigtao River. The alluvion of this placer is much redder than the others and does not possess the same values. In the trench, made for obtaining specimens, of which I shall speak later, where the placer is less eroded, the following section was seen:

1. 0.20 meter Soil.
2. 0.30 meter *Payason* or reddish-brown clay.
3. 0.70 meter *Acaron* or very red clay with pebbles.
4. 0.80 meter *Dugcálon* or sandy clay, rich in gold.

Another similar *banlasan*, commenced on the trail from the pueblo to Pigtao River, was seen.

In another *banlasan* (situated halfway up the bank) on the trail from the

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church to Iponan, and very near the bed of the same, the placer presented the following section:

1. 0.25 meter Soil.
2. 0.80 meter *Acarón* or red and very sticky clay.
3. 0.50 meter *Dugcálon* or pay streak.

Ground from this *banlasan* was taken out and washed with the *bilingan* by way of a practical test.

Placers of Dumalogdog, Camingauan and others.—Directly opposite Pigtao is situated the Valley of Dumalogdog, with its various workings along the banks of the stream and in the sides of the valley, and also the rich localities of Camingauan and Saganahay, names derived from two small arroyos.

By reason of the numerous remains which are to be found there it is to be supposed that the natives must have found the valley of Camingauan very profitable in spite of the scanty topographic relief, there being a little mesa of only 20 meters elevation above the Iponan River. This probably made it very difficult to bring in the water necessary for the different operations. These must have been abandoned three or four years before my visit as their completely ruined and disordered state would indicate, and the characters which the most recent workings present, are found to be almost obliterated in this locality.

In the test pit opened and cleaned out for procuring samples, near the bed of the Iponan River, at the site of the old workings, the alluvion presented the following section:

1. 0.30 meter Soil.
2. 0.80 meter *Acaron* or red clay.
3. 1.20 meters *Dugcálon* or pay streak.

Furthermore, the visible characters of these alluvions are quite similar to those of Pigtao, as might have been expected from their proximity; this is also true of the remainder of the Cayamangon, etc., which one can find all the way to the territory occupied by the Moros. In order to avoid repetitions, I shall not describe them.

2. VALLEY OF THE CAGAYAN RIVER.

Characters of the river.—This river, although one of the most important of the district geographically speaking, is less so as regards gold, at least in that part where one can follow it without danger from the hostile tribes of the interior. This part, however, does not extend more than 5 leagues, notwithstanding the fact that along its course and probably farther into the interior the valley is still flat and cleared, and for that reason easy of access. The fall of the water is quite considerable, especially when it approaches the capital of the district approximately a league from the mouth of the river.

Above Cagayan the river has opened out a bed approximately 40 or 50 meters below the general plain which forms the upper valley of the river. The bed of this river contains more clay and less rock than that of the Iponan, and though in certain places, exceptionally favorable, one can obtain some quantity of very fine gold by washing the muddy gravels which make up its bed, it is of such small importance that the work would not remunerate the workers, and for this reason has received no attention.

Situation of the placer.—The only two placers which are known to-day in the valley of this river are situated in the neighborhood of a pueblo of the *Monteses*, called Munigue, which is situated some 20 kilometers to the south-southeast from Cagayan. The first of these extends in a belt (*faja*) parallel to and near the Bitog River, tributary of the Cagayan River, and the second situated between both rivers, in the place called Calâs.

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Placer of Bitog.—The placer of Bitog is not more than 4 meters in thickness at any of the points at which I have examined it. This, without doubt, is due to the erosion which it has suffered in the past. Some of the zones of which the placer should be composed are lacking; there being present only a part of the *acaron* in some cases, the *dugcálon* complete, but varying more or less in thickness. In one of the *banlasan* which exists there, the most recent of all, situated very close, to the river, the test pit was cleaned out in order to get samples, and the following section observed:

1. 0.30 meter Soil.
2. 1 meter *Acaron* or red clay.
3. 2 meters *Dugcálon* or the pay streak.

The pebbles (cantos) in this placer are less rounded than usual, but very much decomposed. Those of quartz and porphyritic rocks, so abundant in the placers of the Iponan, are here very scarce, presenting, on the other hand, as a new and dominant element some bowlders of the size of a man's head, not very rounded, of orthoclase feldspar,[3] which in some places are so entirely decomposed that they seem to constitute nuclei of very white and pure kaolin. In the lower part of this alluvion there is also seen a very considerable quantity of hematite and magnetic iron in pieces almost angular, and the gold which is found between them is in little flakes and plates of a more red, dirt color and seems purer than that found in the valley of the Iponan River.

The almost complete absence of the eruptive rocks, the presence of feldspar, which is not found in other placers and the better quality of gold which occurs here, induces me to believe that these placers have a different origin from those of the valley of the Iponan, that is to say, that they come from another class of deposits in a rock with a different gangue and finer metal.

Placer of Calao.—In the placer of Calao the same characters are also seen, with the difference that the strata are more clayey and at the same time of greater thickness. The section of the *banlasan* which was cleaned out for collecting samples presented the following zones:

1. 0.20 meter Soil.
2. 0.50 meter *Payason* or a brown clay.
3. 1.10 meters *Acaron* or red clay with pebbles.
4. 2.40 meters *Dugcálon* or the pay streak.

Other placers.—In various localities of the valley of the Cagayan River and of the principal tributaries of the same, there are placers whose character is very similar to those described, especially to that of Calao, for example, the one situated near Munique, close to the junction of the Mangalay and the Cagayan, but the washings of this ground very carefully made with a *bilingan* showed absolutely no values and for this reason there is no remnant nor trace of ancient workings.

3. VALLEY OF THE BIGAAN RIVER.

Situation of the river and character of the beds.—This river with a slight fall and of little geographic importance, runs from south to north as in case of the others.

Not very far from Cagayan it empties into the sea near the town of Gusa. It has its source in the western slopes of the mountain of Tampayong, on the slope of which is situated the only placer known in the valley of this river. Its bed is auriferous, but quite poor, for which reason no work has been done here.

[3] This is unusual, for orthoclase is noticeably lacking in most of the igneous rocks of the Philippines.

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Situation of the placer.—Almost at the source of the river there is on the mountain of Tampayong an arroyo of considerable declivity in its upper part, but gentler in its fall near its junction with the Bigaan, constituting a valley which terminates at the right bank of the river. This valley, which is called Kiondugan, the same as the arroyo through which it runs, contains the placer called Quiliut, the name of a former settlement of *Montcses* a kilometer to the north of the valley.

The placer of Kitondugan.—In this placer there are a number of *tujubs*, or test pits, and various *banlasan* of less importance than those which exist in the valley of the Iponan River, and even less than that of the Cagayan. The most recent of all, which was cleaned out in order to obtain samples, presented the following composition:

1. 0.30 meter Soil.
2. 0.80 meter *Acaron*, very sticky, red clay.
3. 2 meters *Dugcálon* or the pay streak.

This placer contains scarcely any quartz pebbles or eruptives, only some small slaty pebbles, very much decomposed, which could easily be broken and seemed to be pieces of ferruginous clay or indurated ochers. Neither did we see any pebbles of *tonasé* (hematite), or magnetite iron, and the gold which is obtained here by washing is exceedingly fine and in small quantities.

4. THE VALLEY OF THE CUTMAN RIVER.

Situation of the river.—The Cutman River on the eastern flank of the same mountain of Tampayong, rises and runs parallel to the Bigaan toward the north until it empties into the sea at the town of Agusan. It is of greater importance than the latter because its fall is greater and its valley is of greater extension, though there is not much difference in the richness of the placers.

The situation of the placers.—The Bugsug River runs to the west-northwest of a town of the *Montcses*, called Taguiptip, and is one of the tributaries of the Cutman, and in the valley are the placers of Cabalitian and the Libangan, names derived from the two arroyos which traverse them.

Placer of Cabalitian.—The Cabalitian is a little valley with remains of *banlasan*, numerous *tujubs* and worked out pits (rapiña) made in very clayey alluvion, of from 0.50 of a meter to 2 meters in size, pebbles are of slate and quartz and very angular, the gold does not occur in round grains but in dentritic forms very pronouncedly angular, indicating that the formation of this placer is purely local and that it should not be very far from the veins which have been the source of such values as it possesses.

Examining closely the sides of the Valley of Cabalitian and especially the divide between it and the Tiunsan, one finds slates of the crystalline series cut by irregular veinlets of quartz, which possibly form the source of the placer gold, although at the places where I had an opportunity to examine them, they did not give any evidence of containing metallic substance. Furthermore there comes in support of this belief the fact that there is found to the north and not very distant, a similar formation at Pigholugan.

The placer of Libangan.—The placer of Libangan where there are very scanty indications of workings, is even of less importance than the former, both in extent and in richness, and still less than the other alluvial formations of the valley of the Bugsug, which also was not exploited, nor were the sands of this river, nor those of the Cutman, washed.

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Result of the laboratory assays.

Ground from the alluvions.	Grams of gold per cubic meter.	Quilates.	Fineness.
Trench near the church of Pigtao (*dugcálon*)	5.906	16	665
Trench at Caminganan (*dugcálon*)	0.654	16¼	685
Banlasan in Dominolog	3.304	15	625
Banlasan in Bitog	5.536	18	757
Banlasan in Kitondugan	0.765	13½	564
Banlasan in Cabalitian	0.112	14½	600

Result of the practical tests by washing.—The washing, or practical tests, made at some points of the same placers upon a fraction of a cubic meter or less gave the following results:

Ground from the alluvions.

	Grams of gold per cubic meter.
From two abandoned *banlásan* at Pigtao	3.520
From the two at Camiñganan	4.320
Banlásan in Bitog	4.140
Banlásan in Calao	1.130
Banlásan in Kitondugan	0.620

From the observation and comparison of the preceding results it is evident that the *banlásan* of Bitog is comparable in value to the trench at the church in Pigtao, the gold being of better fineness. Second, that the poorest alluvion is that of Cabalitian (Bugsug) and that having the least value is that of Kitondugan (Quiliut). Third, that the average richness of the alluvions of the valley of the Iponan River give a value of 3.288 grams for the assay and 3.556 grams for the washings. Fourth, that this discrepancy is probably due to the fact that the *banlásan* selected for the samples for washings were undoubtedly richer than the part near the river where the trench was opened for taking the samples for the laboratory. Fifth, that in most of the points this anomaly is not noted, although the difference, it seems, should be even more considerable. Sixth, that in general these alluvions have smaller value, but are analogous to those of Russia and quite inferior in value to those of California and Australia.

In conclusion, the regularity of the operations which I have just indicated, their proper organization and use of all the resources which can be obtained in the country and the relatively small cost of the primitive installations, seems to me to leave no doubt but that many, if not all of the placers of the district, could be exploited with good results.

Lode deposits.—As I have several times stated, the only (lode) deposits which are known and which have been partly explored in the district are found in the Hill of Pigholugan, and correspond to the class of contact or metamorphic deposits.

Situation and features.—The Hill of Pigholugan is situated on the right bank of the Cutman River between the arroyos and small valleys or ravines of Cabagcahan and Pigholugan, made up of old metamorphic slates, argillaceous, siliceous, and some steatitic, striking from north-northeast to south-southwest, dipping almost vertically. These slates are crossed by irregular veins of auriferous quartz whose general direction is from east to west, with various deflections

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which follow the same irregularity; with a dip moreover practically vertical and with thicknesses which vary between 0.04 meter and 0.20 meter.

The quartz as a rule is very well crystallized with numerous geodes, in some of which the gold is found in dentritic filaments, also in flasks and plates between the quartz and the walls of the veins. Besides the gold one finds throughout in the quartz in small quantities, little fragments of arsenical pyrites veins which very probably may be auriferous, as is the case with nearly all the pyrites of the Archipelago.

From all that has been said we may deduce the following: First, that in the new district of Misamis there exist auriferous deposits of two classes, placers in the hydro-geological valleys of Bucalalan, Iponan, Cagayan, Bigaan, and Bugsug Rivers, and veins in the Hill of Pigholugan.

Second, that the placers are to-day, and always have been, the chief producers of gold in the district.

Third, that the placers which are the most important by reason of their extent and richness are those in the valley of the Iponan River, while those in the valley of the Cagayan River are best known on account of the values and quality of the gold.

Fourth, that the veins of Pigholugan have a value still little known in spite of their having been worked to a certain extent.

Fifth, that the placers of the Iponan River and the Cagayan River can be exploited profitably provided that the work is conducted with the necessary intelligence.

Sixth, that for this work, the usual proceeding of the country should be modified to some extent and the use of the *bilingan* be replaced entirely by amalgamation.

Seventh, that the veins of Pigholugan, because of their location, are worthy of careful investigation, which can be made without great cost.

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REPORT ON FOREST CONDITIONS IN THE MINING REGION OF AROROY, MASBATE, P. I.[1]

(Excerpt.)

By H. N. WHITFORD.

(*Forester, Chief of the Division of Forest Investigation, Bureau of Forestry.*)

WITH MAP BY

FRED L. PRAY.

(*Forester, Division of Administration, Bureau of Forestry.*)

February, 1907.

VEGETATION TYPES.

As with other parts of the Philippines, the vegetation of the Aroroy mining region may be the original, or that due to the influence of man. The former may be roughly designated as commercial forests, the latter as *cogonales*, cultivated land and noncommercial forests.

COMMERCIAL FORESTS.

As can be seen from the map (Plate XIII) the commercial forests occupy almost two-thirds of the entire area of the two quadrangles under consideration. In a rough way, these forests may be divided into four types, which, for convenience, may be called the river-bottom type, the type of the lower slopes, the exposed ridge type, and the mangrove type.

MINING TIMBERS.

The estimate of stands was mostly confined to the vicinity of the properties of the mining companies. As shown on the map, these regions border on the edge of the commercial forest and grass lands. In all instances, the mines themselves are located in commercial forests. Where these mines are situated well up the slopes, they are within easy reach of the ridge type of forest, in which valuable first-group woods are found. Where they are in the lower-slope type, the most accessible timbers are the cheaper grade timbers. All the timbers that have been cut up to the present time are within easy reach of the tunnels in which they are placed. In one mine *tamayuan* is being used extensively for props and footings. The trees selected are usually about 20 to 30 centimeters in diameter.

[1] While this paper deals with a particular district, it might be taken as applying generally to the lowland districts of the Philippines.

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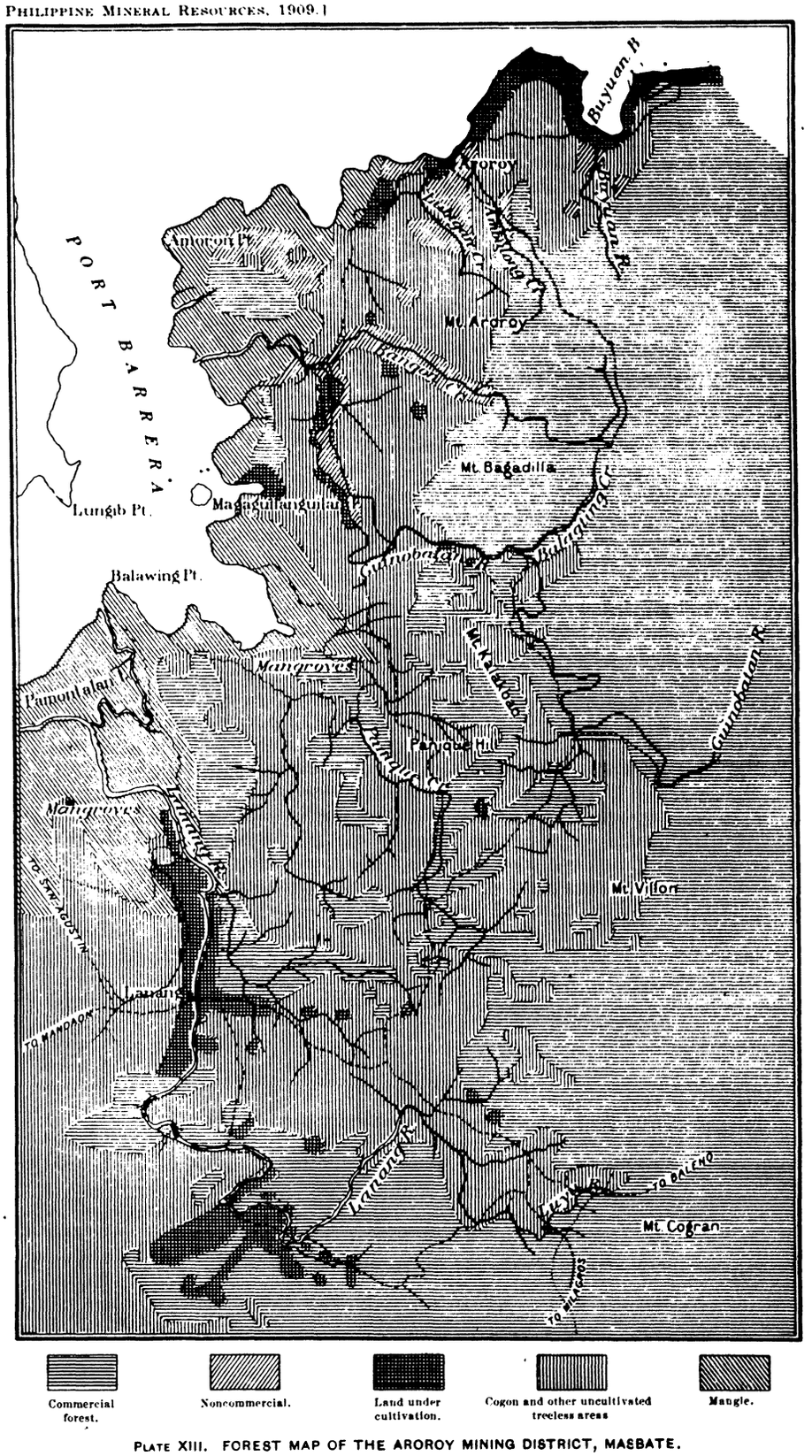

Commercial forest. | Noncommercial. | Land under cultivation. | Cogon and other uncultivated treeless areas | Mangle.

PLATE XIII. FOREST MAP OF THE AROROY MINING DISTRICT, MASBATE.

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Before placing, they are barked, but, so far as observed, no attempt has been made to remove sapwood. Indeed the tree when matured is seldom as large as 37 centimeters in diameter, so that the removal of the sapwood would in many instances leave the log too small for use. In this mine young trees of all timbers in the vicinity are used for siding, especially *lauan*, probably because it is most abundant. In one other mine no attempt had been made to select timbers for props and footings, all being used indiscriminately and placed at once after cutting in the mines, without barking.

The cuttings in the vicinity of the mines are not extensive. With development, however, the demand for timber will be increased. It is to the interest of the companies to utilize the timbers to the best advantage, for if they do not do so, they will soon destroy the forest within easy reach. The custom of removing only small timbers is against all good principles of silvicultural management. It means the destruction of a crop that should be left for future use. The mature crop should be cut first. For *molave* and other first group timber the minimum diameter limit should be fixed at 50 centimeters. While the cutting and preparation of large timbers may entail extra expense that the companies are not now prepared to meet, yet as soon as they are on a firm financial basis, such timber should be utilized. With the power that is necessary to operate stamp mills, etc., they could easily and with little expense install a sawmill, which would enable them to handle the larger trees, the waste of which could be utilized for fuel. Such a step taken now would mean great saving in the future. The history of all mining regions shows this.

Timbers are necessary for two general classes of construction, viz, temporary and permanent. Many temporary tunnels are run in the development of the mines. These can be timbered with the cheaper woods, among which are *lauan* and *toog*. If such tunnels prove to be permanent, the timbers can be replaced. Of course *molave* is the most durable, and it could be used for footings and posts. The supply of *molave* is limited, however, and unless it is utilized with the greatest care, it will soon be exhausted. The same can be said for the other first and second group timbers, such as *narra*, *tindalo*, and *dungon*. As a rule, these timbers should be saved for the most permanent structures, as posts for mills and other buildings and special places in tunnels. *Tamayuan* appears to be more durable than any of the other cheaper grade timbers, but if used exclusively for props, etc., the most accessible supply will soon be exhausted. Little or nothing is known of the comparative durability of the remaining timbers. Two of the most promising of these are *toog* and *dao*. *Magalipac*, *marobo*, and *lauan* are much softer and probably much less durable. There is no doubt that all of these timbers are far less durable than the well-known first and second group woods. Experience alone will tell which are most suitable. *Amuguis*, *guijo*, and *apitong* are of a better grade, but are limited in amount.

TIMBER TREES.

Toog (*Terminalia quadrialata* Merr.).

The tree has a regular unbuttressed bole, which reaches from 80 to 120 centimeters in diameter, and runs from 20 to 30 meters in length. It is a constant associate of *lauan* in the lower-slope type. Here according to estimates based on 6.5 hectares, it averages 12 trees over 30 centimeters in diameter per hectare. In the ridge type, there are 7 trees per hectare, though it is entirely absent on the most exposed situations. The reproducion of *toog* is not good. Few seedlings are present, and a count of 4 hectares shows only about half as many poles per hectare as trees.

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The bark of *toog* is 10 to 12 millimeters in thickness. The outer bark is dark red, nearly black when wet, and has irregular lines of prominent, corky pustules. It is scalloped with irregular depressions as large as saucers, which mark the places of recent shedding. The inner bark is tan-red and very stringy. The proportion of sap to heartwood is about 1 to 4. The heartwood is a dull dark red, resembling somewhat the color of the wood of *dungon*. The wood is said to be fairly durable.

LAUAN (*Parashorea plicata* Brandis).

The bark has flat topped, long or short, anastomosing ridges. It is 10 to 15 millimeters in thickness, and is brown in color. Just beneath the outer bark there is usually a thin, purplish layer. The inner bark has alternating vertical tan-red and white bands, the latter being located beneath the depression. The sapwood is a creamy-yellow; the heartwood is brown to slightly pinkish in color.

The *lauan* of Masbate has a straight, regular bole. It is decidedly the most abundant species of the region, and occurs in pure stands. If it could be utilized, it would be the most valuable tree in the district. As already stated it is found in the lower-slope type, and will thrive on ridges where the soil is sufficiently deep. The reproduction is excellent. Seedlings, saplings and poles are the principal features of the undergrowth in many portions of the lower-slope type.

TAMAYUAN (*Strombosia philippinensis* Rolfe).

This tree is found distributed through the lower-slope type. It forms a conspicuous part of the undergrowth of the lower-slope type. It is a tree that seldom reaches a diameter of 40 centimeters when mature.

The bark is 5 to 12 millimeters thick. The outer bark is smooth, dark brown, nearly black, and is covered with lines of corky pustules. This is shed in large irregular plates, and the new bark thus exposed is cinnamon-brown in color. The inner bark is yellow, with white concentric bands. The bole is usually slightly irregular.

The wood is hard and probably quite durable, although there is as yet little reliable information concerning its durability. The sapwood has a very slight reddish or purplish tint, which becomes more pronounced in the heartwood. The line between the heart and sapwood is very irregular, sometimes forks of the former extending into the latter. This wood is one of the most promising of the mining timbers. It is used almost exclusively by one company for props and footings.

DUNGON (*Tarrietia sylvatica* Merr.).

This tree is distinctly of the ridge type, where it reaches its best development, although here it averages only 28 trees per hectare. The bark of *dungon* is 8 to 10 millimeters in thickness. The outer bark is cinnamon-brown, ashy-gray in color, and is covered with corky pustules. It looks much like *guijo*. It is shed in large scroll-like patterns. The inner bark has a delicate pink-tan color with fine concentric lines. The proportion of sapwood to heartwood is about 1 to 4. The former is white, lightly tinged with red, and the latter is a very dark brownish-red. The tree has an irregular bole and is sometimes strongly buttressed. The largest tree noted had a diameter of about 80 centimeters and a clear length of at least 15 meters. The reproduction of *dungon* is fairly good. Seedlings, saplings and poles form a proportional share of the undergrowth near the mature trees. The tree, while intolerant, is slightly less so than its associates, *molave* and *tindalo*.

Dungon is one of the most durable timbers of the region, but because of its limited quality, should be used sparingly.

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TINDALO (*Pahudia rhomboidea* Prain).

Tindalo is distinctly a ridge-type tree, but even here it is very scattered, forming only 15 trees per hectare.

The bark of *tindalo* is about 10 millimeters thick. The outer bark is creamy-yellow in color, is uneven on the surface, and is covered with corky pustules. This uneven surface is due to the saucer-like depressions left when the bark is shed. The inner bark is brownish-yellow in color.

The reproduction of *tindalo* is poor. All trees noted were mature or nearly mature.

MOLAVE (*Vitex parviflora* Juss.).

Molave belongs distinctly to the ridge type of forest, where, according to the estimates made, it averages 2.4 trees per acre.

The bark of *molave* is 8 to 10 millimeters thick. The outer bark is a light-yellow-brown, and has a smooth, slightly shreddy, but uneven surface. The inner bark is light yellowish with darker yellowish concentric rings. It quickly turns brown on exposure. The bole of the tree is very irregular and often shows a spirally twisted trunk.

The reproduction of *molave* is exceedingly poor, although a constant search was made for seedlings, none were found. Indeed, the smallest tree noted was 20 centimeters in diameter, although many of the trees were in flower or fruit. The tree is exceedingly intolerant of shade, and consequently occupies the most open places. It is more abundant on the border of grass land than elsewhere. Colonies of trees, gnarled and stunted in growth, are often found isolated on rocky ridges in the cogonales themselves. That the tree does not occupy the drier ridges from choice is evidenced by the fact that occasional trees were noted in open places in the lower slope, and even in the river-bottom types. Especially is this true along the border of the narrow strips of forest in the cogonales that skirt the streams. The appearance of *molave* on the dioritic rocks of this region shows conclusively that it is not confined to limestone rocks, as is commonly believed.

Molave is the most abundant and most durable of the woods of the region. Many of the trees, while old and decayed, contain a sufficient amount of sound wood for construction purposes. Since the tree is failing to reproduce, no future crop is coming to replace the present one.

GUIJO (*Shorea guiso* Blume).

Guijo is found in very limited quantities in the lower-slope type. The bark is 7 millimeters thick; the outer bark is cinnamon-brown in color where freshly shed, and thickly set with corky pustules. The darker, older bark breaks in vertical flakes. The inner bark is brown tan to cream color, tinged with tan. The trunk is straight, cylindrical and clear of defects.

NARRA (*Pterocarpus indicus* Willd.).

Narra, although most abundant in the river-bottom type is not confined entirely to that, for the lower slope type shows 1.5 trees per hectare, and even on the dry ridges there are scattering trees.

The bark of *narra* is 3 to 5 millimeters in thickness, the outer bark is brown to olive-gray in color, soft and minutely flaky. The inner bark is light red, streaked with darker red, short tubes, united in vertical rows. These tubes, on being cut, exude a dark red sap which, on solidification, becomes very reddish-brown in color. *Narra* is not quite so intolerant of shade as *molave*. So far as tolerance is concerned the ridge type would be an ideal place for it, but here the

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soil conditions are probably too dry at certain seasons of the year. If it were more tolerant, the lower-slope type would be the ideal place for it, as evidenced by the fact that it here reaches its best development. It is, however, usually crowded to the borders of streams, where, besides a sufficient supply of moisture, it has better light conditions than can be obtained in the close forests of the lower-slope type. The reproduction of *narra* is fairly good. In open places, near seed trees, many seedlings are often present; away from these there are scarcely any.

Narra is a durable wood in contact with the ground, but because of its limited supply and because of its high value for cabinet wood, it should be used sparingly for construction work.

AMUGUIS (*Koodersiodendron pinnatum* Merr.).

Amuguis follows *narra* in its distribution, being most abundant in the river-bottom type, less so on the lower-slope type and almost entirely wanting in the ridge type. It is a good general construction timber where it is not in contact with the soil. It is, however, probably much more durable in contact with the soil than many of the fourth-group timbers.

DAO (*Dracontomelum dao* (Bl.) Merr. & Rolfe).

Dao is one of the most promising of the little, or not at all used timbers. The tree is constantly associated with *narra* and *amuguis* in the river-bottom type, to which type it is almost entirely restricted.

HAGACHAC or APITONG (*Dipterocarpus affinis* Brandis).

This tree known locally as *apitong*, is almost entirely restricted to the river-bottom type. Here it occurs in pure stands which are extremely limited in area, because the physiographic type in which it grows is so limited. *Hagachac* can be readily distinguished from the true *apitong* (*Dipterocarpus grandiflorus*) by the fact that it has hairy leaves, while the leaves and petioles of *apitong* are smooth. There is little doubt, but that *hagachac* is as good a constructive timber as *apitong*. It, like *apitong*, is not considered durable in contact with the ground, but is probably more so than any of the fourth-group timbers herein mentioned.

MAGALIPAC (*Sterculia blancoi* Rolfe).

This is a timber that occupies first place in abundance in the ridge type, and is third in the lower-slope type. It is a timber that is as soft or softer than *lauan*, and is probably not durable, although experiments alone will show this.

MAROBO (*Diplodiscus paniculatus* Turcz.).

Marobo is a little known timber that occupies fourth place in abundance in the ridge type. Nothing is known about its durability.

Other timbers that deserve mention are *malaguibuyo* (*Celtis* sp.); *Artocarpus* sp. (*cubi*); *Trewia ambigua* Merr. (*matobato*), *Terminalia nitens* Presl. (*magatalisay*), *Nauclea* sp. (*calamansanay*), and *Kingiodendron alternifolium* (Elm.) Merr.

Little or nothing is known of *malaguibuyo*. It is closely related to a species known as *malaicmo*. It is not durable. *Cubi* is identical with or closely related to the *anubing* of commerce. It is known to be durable in contact with the ground. While only two trees were noted, a more careful search might show that there are localities where it is found to be more abundant. *Magatalisay* is the *sacat* of commerce, and is valuable for light construction purposes. *Matobato* is said

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to be quite durable, and is ranked with *tamayuan*. It is little used, however, probably because it is not abundant. *Batete* is another wood the qualities of durability of which are little or not at all known. It forms almost pure stands in some portions of Masbate, and is used locally for floors and siding in house construction. It is shipped to Manila in limited quantities.

THE MANGROVE SWAMPS.

On the east side of Barrera Bay there are two areas of mangrove swamps (mangles), occupying in all some 10 square kilometers (2,500 acres). These lie at the mouths of the Guinobatan and Lanang Rivers. The latter is most extensive, and, except for narrow strips along both margins of the river, has been little utilized. The woods of these swamps are most valuable for firewood. The wood is cut at a contract cost of ₱2.25 per cord, and is transported in a barge a distance of about 5 kilometers for ₱1.25 per cord. This makes a total cost of ₱3.50 per cord.

On account of lack of time no attempt was made to estimate the number of cords per acre. Until such an estimate is made, no accurate information can be given about the number of cords of wood in this mangle. However, it can be stated that at the present crop, this excellent wood supply will last a great many years. Reproduction is excellent, and long before the present area can be cut over, sufficient time will have elapsed to restock the areas first cut over. The danger lies in cutting too closely the forest within easy reach of water transportation. As the edge of the cuttings is pushed back from the banks of the streams and large esteros, the difficulty of transportation will be increased. Although not thoroughly investigated, it is believed that the area within immediate reach of the waterways is so large that a judicious selection of mature timber will bring about a rotation of crops that will keep the cutting area indefinitely within easy reach, so that all firewood can be cut and loaded on boats with little or no land transportation. To be sure, mangrove swamps are so interlaced with tidal channels that the entire body of timber is no great distance from the water's edge, but many of these channels are too small to allow the entrance of barges. The extra handling of the wood along such channels will add materially to the cost. It is therefore to the interest of the company so to conduct their cutting operations as to avoid this extra handling.

A careful study of the conditions in this swamp including estimates of the number of cords of wood per acre and a scheme for proper rotation of crops, etc., would furnish material for a plan to exploit the mangle economically. I have seen no better place in the Islands to study mangrove vegetation than in Barrera Bay.

DURABILITY TESTS.

Arrangements were made with three mining companies to label timbers placed in the mines, in the construction of mills, etc. For this purpose blank forms were furnished the companies, to be filled out by them when such timbers are placed. Copper labels were also left with them in order that the timbers could be properly marked.

Following are the lists of timbers suggested to them:

Mount Cogran Mining Company (copper labels 1 to 12), *dungon, letis* or *betis, toog, tamayuan, lauan, bansalguin, magalipac, marobo, apitong* (*hagachac*), *guijo* (*guiso*), and *amuguis.*

Colorado Mining Company (copper labels 22 to 35), *dungon, tindalo, molave, palo maria, dao, toog, calamansanay, magalipac, marobo, lauan, tamayuan,* and *narra.*

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Eastern Mining Company (copper labels 35 to 50), *dungon, calamansanay, narra, tindalo, tamayuan, lauan, magalipac, bansalaguin, toog, dao, marobo, malaguibuyo, amuguis, molave* and *matobato.*

The lists given are merely suggestive, but they include some of the most durable, as well as all of the most abundant, but commonly reputed to be undurable, timbers. It is upon such timbers that the companies will have to depend for their supply, hence such information as can be obtained by them will be of lasting value.

It is a well-known fact that timbers of equal quality will last longer in temperate than in tropical regions. This is due to the devastating action of the white ant and fungus growth. The former is not present in temperate regions, and because of continuous warmth and almost continuous moisture, fungi are more destructive in the Tropics. While it is true that there are few timbers like *molave* that will last longer in tropical conditions than the best timbers of temperate zones, yet most of the tropical timbers are exceedingly rapid in decay. However, these same timbers, if used in similar situations in temperate zones, would probably last as long, if not longer, than many of the woods used there. This goes to show that the tropical miner can not expect the common timbers that are placed in his mines to last as long as his experience in temperate regions has seemed to teach him they should last. Many of the timbers now thought to be of little value would probably outlast the common trees of temperate zones in exactly the same conditions. It will be seen that the timbers which decay rapidly are the most abundant. It is believed that if these timbers are properly preserved, they will last as long, if not longer than the more durable ones, and that it would pay the companies to put in preserving plants of some kind. The Bureau of Forestry is in a position to advise companies concerning the kinds needed and the cost of the same.

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ABSTRACT OF PHILIPPINE MINING LAW.

By H. G. Ferguson.

The basis of the present Philippine Mining Law is contained in sections 20 to 62 of the Act of Congress approved July 1, 1902, amended as regards several sections by section 9 of the Act of Congress approved February 5, 1905. Various Acts of the Philippine Government have amplified these provisions.

In the Act of Congress the following are the most important provisions:

Section 21 provides for the taking up of claims by the citizens of the United States or of the Philippine Islands and forbids the working of mineral deposits under agricultural title.

Section 22 defines a mineral claim and fixes the size of a claim as a square of 300 meters on a side.

Sections 23 and 26 deal with the methods of locating claims.

Section 27, one of the most important in the Act, defines the boundaries of a claim as extending vertically downward thus doing away with the extra-lateral rights which have been such a fruitful source of trouble in American mining.

Sections 27 to 32 deal with details of recording claims and designate the various provincial secretaries as mining recorders until other officers shall be appointed by the Philippine Government.

Section 33 states "that no holder shall be entitled to hold in his, its, or their own name or in the name of other person, corporation ,or association more than one mineral claim on the same lode." In an opinion of the Attorney-General it is held that this section does not prohibit the holding of any number of patented claims by a person or corporation.

Section 34 provides for notice of abandonment and section 35 for affidavits of citizenship. Section 36 deals with assessment work and provides that annual labor to the value of ₱200 shall be performed on each claim.

The period for which the work is required does not commence until the 1st of January succeeding the date of location, so that the holder of a claim located the 1st of January has two years in which to perform his first work. As there is no provision for discovery work, many claims are held from year to year without any development, the holder simply relocating either in his own or another's name whenever it becomes necessary.

Sections 37 and 38 deal with the granting of patents, the requirements for which are a survey made by or under the direction of the Bureau of Lands, at the expense of the holder, the performance of a thousand pesos worth of development work and the advertisement of the application for a period of sixty days. If there is no adverse claimant, a patent may be granted on payment of ₱25 per hectare.

Section 39 provides that an adverse claimant must commence proceedings in a court of competent jurisdiction (the Court of First Instance for that district)

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within thirty days after filing his claim and prosecute the same with "due diligence."

Section 40 deals with mineral on lands already surveyed.

Sections 41 and 42 provide that claims for building stone and petroleum are to be entered as placer claims.

Section 43 allows placer locations to the extent of 64 hectares for an association and 8 hectares for an individual. This section does not, however, provide that such association or individuals shall be limited to one location.

Section 44 requires that placer locations shall conform to legal subdivisions of public lands. No such subdivisions have as yet been made.

Section 45 allows patents to be acquired by working a claim for a period equal to the time prescribed by the statutes of limitations.

Section 46 gives the Chief of the Bureau of Lands power to appoint deputy mineral surveyors and to fix maximum charges for surveys and advertisements.

Section 47 deals with the verification of affidavits and contests as to the character of land.

Section 48 allows the location of land, not contiguous to a lode, not to exceed 2 hectares, for mining or milling purpose.

Section 49 gives the Philippine Government the right to provide rules for the regulation of mining.

Section 50 and 51 deal with the protection of vested water rights.

Section 52 allows the Philippine Government to establish land districts and appoint the necessary officers. This has not been done as yet.

Sections 53 to 57, inclusive, form the Coal Land Law of the Philippine Islands. These provide that any citizen of the United States or the Philippine Islands or an association of such persons may enter coal lands to the extent of 64 hectares to an individual or 128 to an association upon payment of not less than ₱50 per hectare if the land is situated more than 25 kilometers from a railroad, navigable stream or not less than ₱100 per hectare if the land is within this distance. This payment is to be made within a year of the date of filing the claims, which itself must be within sixty days after the date of location, otherwise the land is open to relocation.

Section 58 provides that saline lands may be sold at public auction at a price of not less than ₱6 per hectare.

Section 59 reserves mineral lands from land grants.

Section 60 assures the validity of Spanish concessions perfected before April 11, 1899, provided that the owners of such concession shall mark their corners by permanent monuments within six months after the passage of this Act, failure to do so leaving the land open to exploration and purchase.

Section 61 provides that mining claims shall be acquired only in accordance with this Act.

Section 62 provides for the procedure necessary for the cancellation of perfected Spanish concessions.

Three Acts of the Philippine Government (Nos. 624, amended by various later Acts, 1124, and 1947) amplify the provisions of this law.

Act No. 624 defines a *mineral claim* as a *lode claim*, a *mining claim* to include both *lode* and *placer* claims and includes under the term *placer, claims* for placer mining, stone quarrying and for securing earth, petroleum, and guano.

The Act also provides a form of location notices, and annual assessment work, and gives detailed directions for the location of claims.

Act No. 1128 deals with coal lands in the same manner and provides in detail for location, payment, patents, adverse claims, etc.

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Act No. 1947, enacted May, 1909, validates certain Spanish concessions, the holders of which while acting in good faith had not complied with the requirements of the law. The claims so validated are for the most part situated in the Provinces of Ambos Camarines, Cebu, and Surigao. The conditions under which title is given cover the continuous and proper mining of the concessions and the fulfillment of all other provisions of the Royal Decrees of 1867, not in conflict with later legislation, including the payment of a 3 per cent royalty, and require the holder to apply for registration of his title within two years from the passage of the Act.

As will be seen from a study of the Act of Congress certain of the provisions are so stringent as to work great hardship upon the mining industry. Those particularly hurtful are sections 33 and 36 and the too severe provisions of the sections relating to coal lands, and it is earnestly hoped that Congress will soon afford us relief in these particulars.

A pamphlet containing in full the Mining Laws of the Philippines has been issued by the Bureau of Lands and may be had upon application to the Bureau of Printing, Manila.

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INDO-MALAYAN WOODS

BY

FRED W. FOXWORTHY.

ORDER No. 411.

(Being Section C, No. 4, Vol. IV, of the Philippine Journal of Science.)

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   - *d.* Odor, color, taste.

III. Suitability of different woods for special purposes.
   - *a.* Enemies of wood.
   - *b.* Woods exposed to salt water.
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THE HEADWATERS MILL.

PLATE I.

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GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF THE INTERIOR
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS

WITH A STATEMENT OF THE PRODUCTION
OF COMMERCIAL MINERAL PRODUCTS
DURING THE YEAR 1910

ISSUED BY THE DIVISION OF GEOLOGY AND MINES
BUREAU OF SCIENCE

WARREN D. SMITH, *Chief*

MANILA
BUREAU OF PRINTING
1911

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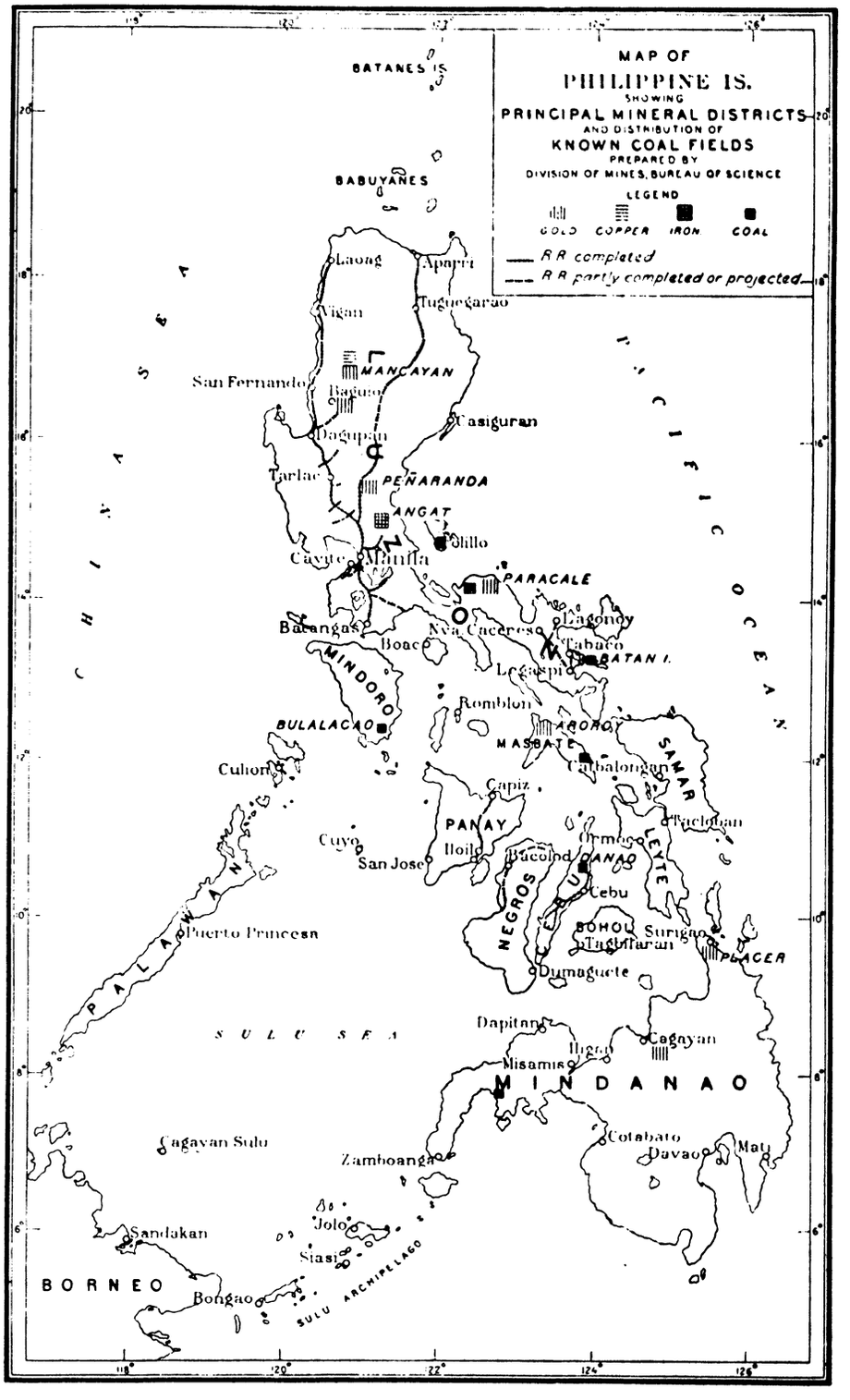

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STATISTICS OF PRODUCTION.

By F. T. EDDINGFIELD.

TABLE I.—*Mineral production in 1910.*

[In pesos [a] Philippine currency.]

Province.	Gold.	Silver. [b]	Copper.	Iron.	Manganese. [c]	Coal.
Albay						172,955
Ambos Camarines	144,900					
Bulacan				20,023		
Cebu						3,300
Ilocos Sur	[d] 1,000					
Masbate	(e)					
Mindanao	[d] 40,000					
Mountain Province	[d] 95,960		(f)			
Nueva Ecija	[d] 25,000					
Pangasinan	[d] 2,000					
Total	308,860			20,023		[g] 176,255

Total metallic with coal	505,138
Total nonmetallic	1,541,031
General total	2,046,169

TABLE II.—*Comparative statement of mineral production in 1907, 1908, 1909, and 1910.*

[In pesos [a] Philippine currency.]

Year.	Gold.	Silver.	Copper.	Iron.	Manganese.	Coal.	Non-metallic.
1907	141,194.00	95.53				26,799.00	
1908	431,500.00	2,750.00	52.00	17,500.00		77,166.00	815,918.00
1909	495,194.00			31,078.00	12,500.00	197,184.00	1,504,091.00
1910	308,860.00			20,023.00		176,255.00	1,541,031.00

[a] One peso Philippine currency is equal to 50 cents United States currency.
[b] Some silver generally found alloyed with Philippine gold. None is mined separately.
[c] No manganese reported for 1909, but several new deposits were found.
[d] Includes estimated amounts produced by natives.
[e] No mills running.
[f] Small amounts smelted by Igorots.
[g] 28,655 tons at 6.50 pesos per ton.

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INTRODUCTION.

By F. T. EDDINGFIELD.

The year 1910 has been characterized by the greatest activity in the history of mining in the Philippines, yet the production of gold fell to but little more than 60 per cent of the previous year, and all the other mine products suffered a reduction. The reasons are given below:

The year 1909 closed with a damaging flood in Benguet which tore away the entire cyanide plant of the Consolidated mine and greatly delayed the Bua, since when the mines have been worked but very little. Later, severe storms swept through the south causing considerable damage to the San Mauricio and hindering the work of construction in Masbate. Still later the Philippines and Stanley dredges stopped work and the old Paracale dredge sank. Then the San Mauricio, the mine most anxiously watched by everyone, suspended operations and discouraging reports came from the Tumbaga.

Such an array of calamities would have been enough to dishearten a much more advanced country than this, but they affected the continued development but little. The operators seemed to realize that a few failures of hastily planned enterprises were no indication of the true worth of the ore bodies, and consequently began slowly to start operations on a more solid basis.

In Benguet, the Major Mines Company erected a six-stamp mill with concentrating tables and spent large sums in surface construction, houses, sawmill, ore bins, tramways, roads, etc., preparatory to taking out ore. The Headwaters Company began the installation of a ten-stamp mill with complete cyanide equipment, and Mr. McElroy built a three-stamp mill. The Consolidated again began operating on a paying basis and the Bua tore down the old mill with the hope of building a larger one in a more suitable location. Farther south in Benguet, near the Pangasinan line, Messrs. McMichaels and Lambert are preparing to erect a Huntington mill on their property at Lubang. All of these companies have been pushing development work, as have many others in this district, although at present without any mills, and a large number of promising showings have been encountered.

In Nueva Ecija and the adjoining country to the east, paying placer deposits have been met with and arrangements have been made for installing dredges. Platinum has been found in this district, and the country to the south.

In Ambos Camarines, the Paracale Company built a new pontoon and put up a crusher and Huntington mill for treating the rich boulders raised by the dredge; the Philippines dredge was moved to the Maliguit River where it has at last proved a success; and arrangements have been made to build a dredge on the Gumaus River.

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In Masbate, the Colorado Company is erecting a twenty-stamp mill and cyanide plant, and several other companies have started with renewed activity to develop ore and prepare for mills.

In Marinduque an English company has carried on operations and erected a three-stamp mill with concentration tables on a property 20 kilometers south of Santa Cruz.

Numerous good reports continually come from Surigao, Mindanao, where several Americans are prospecting placer ground. Mindoro also shows promise in this direction, and it is very probable that dredges or some sluicing machinery will be placed in one of these districts before long.

This present year will be an improvement over all the previous ones, for conservative men have been investing in a conservative manner.

THIS BULLETIN INCLUDES DATA UP TO JUNE 30, 1911; IT WAS ISSUED NOVEMBER 10, 1911.

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AROROY MINERAL DISTRICT.

By F. T. EDDINGFIELD.

The geology of the Island of Masbate, the character and location of the ore veins, and the general conditions of the district, have been discussed by Mr. H. G. Ferguson in an article which will appear in the Philippine Journal of Science. However, since Mr. Ferguson's article was written, much development work has been done on several properties, sufficient in some cases to change the entire outlook of the prospect; and in addition construction work has been going on preparatory to milling.

The mineral district is about 4 kilometers wide and 20 kilometers long, although most of the veins occur in an area about 4 by 8 kilometers. The majority of the veins strike N. 45° W., but a few small ones strike E. and W., N. and S., and one or two NE. and SW.

There were at least two periods of fissuring and vein filling, as indicated by the faulting of one vein by another on Kalakbao. The region shows great movement and faulting, probably due to the igneous intrusions of the Panique series, which consist of dacites, augite-andesites, hornblende-andesites, basalts, and leucite tephrites.[1] It is probable that a large number of these veins occur on the contacts of the intrusions and that many others are formed in fault fissures, which would explain the irregularity of the walls and the presence of "horses" in the veins.

THE COLORADO MINE.

The Colorado mine is located on Bagadilla Mountain, and the vein on which most of the development work has been done outcrops very near the crest of the hill, striking about S. 45° E. dipping 70° to the NE. The highest point of the vein is about 320 meters above sea level and fully 290 meters above the boiler floor of the mill.

There are two main tunnels driven along the foot wall of the vein. No. 1 is 30 meters below the highest point in the outcrop, and opens up the vein for a distance of 210 meters, No. 2 is 55 meters on the incline below No. 1 and opens up the vein for a distance of 380 meters. A third level, known as the "intermediate," is being driven 20 meters above No. 2, connecting three raises from No. 2 with the main shaft. These raises contain ore chutes and manways ready for stoping on the intermediate. On the first level, crosscuts have been

[1] Identified by H. G. Ferguson.

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driven at short intervals to the hanging wall and drifts have been driven in both directions along the hanging wall to connect the crosscuts, forming a main haulage way.

A two-compartment incline shaft was sunk on the vein from the SE. opening of No. 1 to a depth of 122 meters on the incline. Crosscuts were driven between the walls of the vein at intervals of about 15 meters down the shaft.

The vein varies in width from 3 to 12 meters, but averages about 5 meters. It is a quartz manganese vein containing calcite in depth, but honey-combed in the upper levels from the leaching away of the calcite. It presents a very marked ribbon or banded appearance from the layers of quartz, iron, and manganese. This banding is generally parallel to the walls, but in some places it is seen in circular form, probably because of movement in the fissure. Numerous irregularities occur in the dip and strike of the walls, and horses of wall rock are frequently encountered in the vein. These features are characteristic of the district as a whole.

The hanging wall of the vein is a much decomposed andesite. The foot wall has the appearance of being a separate intrusion of a highly mineralized, light-colored, semi-granitic mass filled with impregnated quartz, having a width of about 20 meters on the second level. This seems to indicate that the vein is a contact deposit.

Oxidation has been carried on to a greater depth in this district than in any other known section of the Islands. The ore is in a much oxidized state even at the foot of the shaft, but the wall rock is only slightly altered.

Water should cause no trouble in the mine for almost one hundred meters more in depth. This presents a possibility of developing over one million tons of ore above the permanent water level.

The vein is said to average 14 dollars to the ton, along the No. 1 and No. 2 drifts. Some values as low as 8 dollars and as high as 60 dollars were reported, showing irregularity in the distribution of values in various parts of the vein. However, it is a peculiar fact that a careful screening test of a sample of ore showed practically equal values for eight different screen products. The ore cyanides well, requiring but little lime for alkalinity and showing a good extraction of values with a moderate consumption of cyanide.

The ore will all be taken out of the second level and lowered to the mill in a Seschen two-bucket rope tramway 320 meters long, having a pitch of 26°. The mill has the following process:

(1) Grizzly bars and crusher. (2) Ore bins, 200-ton capacity. (3) Challenge ore feeders. (4) Stamp battery, 20 stamps, 1,250 pounds each. (5) Dorr classifier. (6a) Sands to 2 tube mills, 56 inches by 16 feet. (6b) Elevator to Dorr classifier. (6c) Slimes from Dorr classifier to Dorr thickening tank, 14 feet by 28 feet. (7a) Overflow to tank, 5 feet by 6 feet. (7b) Triplex pump, to (7c) battery storage tank, 16 feet by 24 feet, on orebin level. (7d) Underflow Dorr thickener to 2 air lift Pachuca tanks, 40 feet by 12 feet diameter. (8) Second Dorr thickener. (8a) Overflow to clarifying boxes. (8b) Zinc boxes. (8c) Sump. (8d) Triplex pump, to (8e) strong solution tank, 8 feet by 20 feet diameter. (8f) Underflow of Dorr thickener to agitation tank, 8 feet by

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20 feet. (9) Two Oliver filters. (9a) Solution, to wet vacuum pump, to (9b) storage tank. (9c) Centrifugal pump to (9d) Second zinc boxes, (9e) to sump or to Oliver filter for wash solution. (9f) Pulp, to waste dump.

Water is obtained from 14 wells in series located below the mill. It is pumped to one high-head storage tank above the mill and one low-head storage tank on the second Dorr thickener level.

The power plant consists of three 100 horsepower boilers, and one 250 horsepower Bates-Corliss engine with hemp rope drive.

The location is very favorable. Wood for fuel is moderately cheap and plentiful. The mill is about 1 kilometer from the nearest navigable stream, and only about 5 kilometers from a good harbor.

THE EASTERN MINE.

This property is located on the central part of Kalakbao Hill. It contains two large veins which strike approximately N. 45 W. and dip about 70° to the SW. They outcrop near the crest of and parallel to the direction of the hill. The entire hillside to the NE. is covered with quartz from the wash of these veins. This wash has been worked by natives to recover the gold and is full of small shafts and workings.

The veins have been formed in fissures in a much fractured zone caused by several intrusions of igneous rocks. The hanging wall is a much oxidized porphyry, probably an andesite, while the foot wall of the smaller vein varies in different parts, but probably consists of different phases of the andesite. The vein filling is quartz and calcite, containing iron, manganese, copper, and gold. Horses of country rock are frequently encountered. The outlines of the ore bodies are very irregular as can be seen from the accompanying map of the workings.

The smaller of the two veins is now called No. 1, although spoken of as No. 2 in Mr. Ferguson's paper. It is included between the two dotted lines, lying NE. of No. 2. Its width is very irregular, but the best ore lies on the foot wall, in a band 5 meters wide. The assay sheet shows an average of over 14 dollars per ton for a distance of 120 meters along the vein. Several winzes have been sunk near the foot wall and show good values for a depth of over 31 meters. Copper was encountered in one of these winzes. This, coupled with the fact that No. 1 vein has a very different appearance from No. 2, being more compact and solid with less manganese and less banding, leads to the conclusion that the two veins represent two different periods of fissuring and vein filling. This idea is strengthened by the fact that the dip of No. 1 in the bottom of the winzes seems to indicate that the two veins will not join in depth.

No. 2 vein is very large, averaging 20 meters. It is for the most part characterized by banding of the quartz, iron, manganese, and calcite. In many places the vein is almost wholly calcite, and in such places the values are usually poor. The ore is less compact than in No. 1, and contains no copper. Several examinations of this vein have been made by engineers, but the values were so irregular that no definite paying ore body could be blocked out.

Fully 1,000 meters of drifts and crosscuts have been driven in the two veins on three levels as indicated on the map, while about 90 meters of winzes and raises have been driven. The first level is for the most part less than 30 meters below the outcrop, the second is 23 meters lower, and the third 34 meters below No. 2, making a total of 80 meters or more above the third level.

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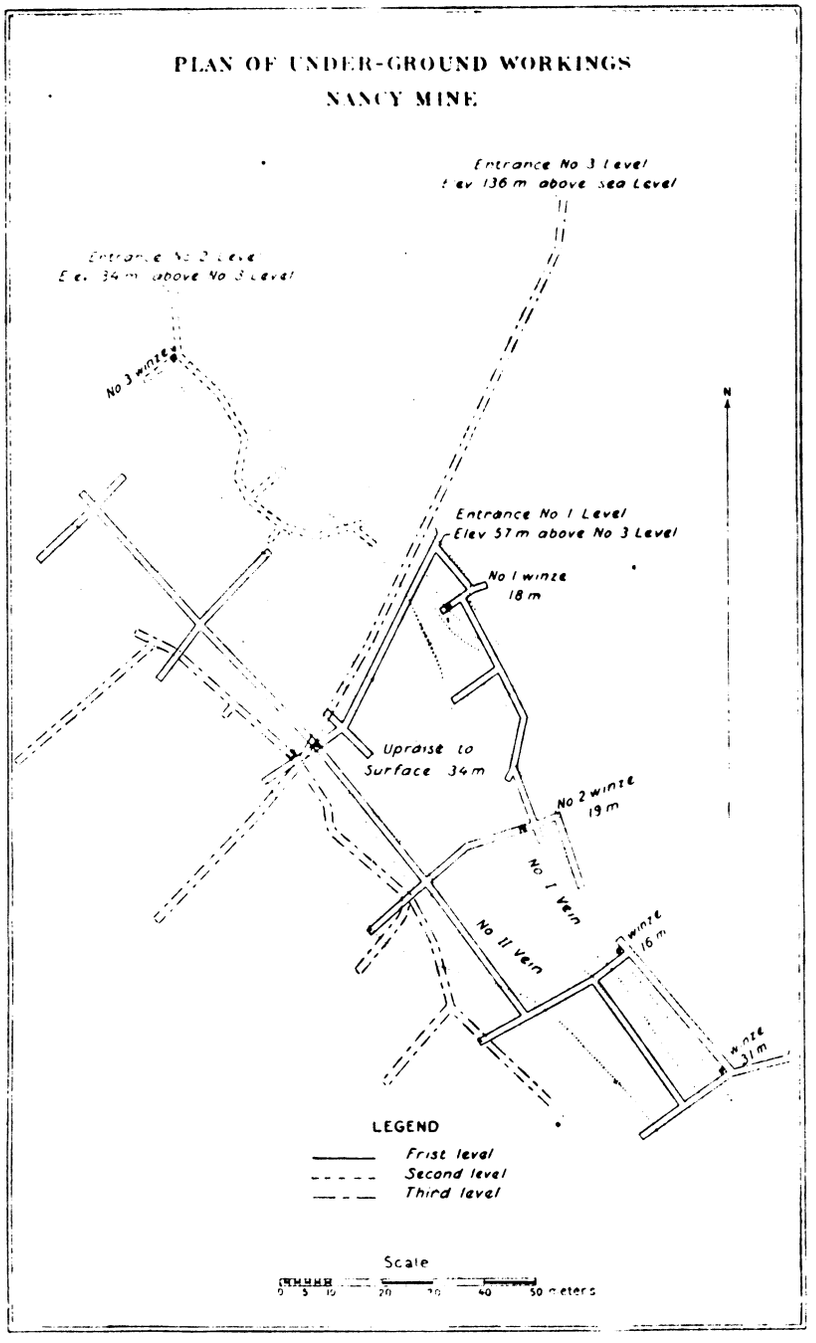

FIG. 1.

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No. 1 vein appears to be remarkably good in all the places opened up, and above the second level alone would represent a mine which should prove very profitable. It presents a possibility of having over 100,000 tons of ore averaging 9 to 10 dollars per ton.

OTHER PROPERTIES.

The Tengo Mining Company is developing a new vein and repairing the ten-stamp mill which was placed on the property several years ago. Mr. P. A. Schwab is prospecting some narrow veins which contain visible gold, an unusual occurrence in Masbate. The Keystone Mining Company is prospecting some claims on Aroroy Mountain. They have installed air drills, the first used in the Islands for mining purposes.

Other properties in the district are El Sol, Hayes, Nebraska Star, and Gold Bug. The last named has a ten-stamp mill standing idle.

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PLATE III.

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DEVELOPMENTS IN THE BAGUIO DISTRICT.

By WARREN D. SMITH.

If the statistics of production alone were to be considered, then the past year has been one of stagnation and suspension of work, in this district, but an examination of the properties shows that it has been one of recuperation and preparation for more active operations.

BENGUET CONSOLIDATED COMPANY.

The Benguet Consolidated Mill and the Bua Mill suffered severely from a storm in October, 1909. The latter suspended all operations, but the former continued development work and has consistently turned out over 100 ounces of bullion per month from its amalgamating plates. The company is more than making expenses and the mine has been kept in excellent condition. There is no question but that this company controls one of the largest ore bodies in the Philippine Islands.

THE HEADWATERS MINING COMPANY.

The Headwaters Mine, located on the headwaters of the Antamok River, has recently completed the installation of an all-sliming cyanide plant consisting of the following:

Rock crusher, ten-stamp Hendy mill, classifier, Hardinge conical mill, Frenier sand pump, classifier, slimes thickener tank, 2 Pachuca tanks for air agitation, pulp tanks, gold solution tanks, storage tanks, Ridgeway vacuum filter with necessary pumps, zinc boxes, Pelton water wheel, gasoline driving engine, and air compressor.

This mine has a fair supply of ore blocked out on a strong lead which can be traced for several thousand feet on the surface and which is reported to average 16 pesos to the ton. Samples taken by members of the Division of Mines have run much higher.

OTHER PROPERTIES.

The Major Mining Company on Major Creek, one of the numerous branches of Gold Creek has in operation a six-stamp Hendy mill and intends shortly to put in a small cyanide plant.

The Comote-Clayton property, which lies east of the Benguet Consolidated, presents some very good free-milling ore and the three-stamp mill which was erected several years ago is again being placed in condition. This mill is small but should yield a profit on the rich ores of the property.

The Muyot Mining Company has not as yet installed machinery. However, its mine to-day is probably among those, which have not yet begun milling, the best developed property in the district.

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Mr. J. E. Kelly, at Bua, has four strong leads which give promise of developing a large deposit of rich ore.

Mr. H. O. Hibbert, the locator of the Headwaters property, has taken over a large interest in the mine and claims of Mr. J. P. MacElroy on Emerald Creek. Mr. MacElroy, previous to the sale, had installed a three-stamp mill which was made in Manila.

Other properties are held by Mr. J. E. Huiskamp in Batwaan; Mr. Calvin Horr, on the Ascension group, located near the Kias trail, and by Mr. Alexander Pau on the property north of the Major Group. All are carrying on development work and have uncovered some promising leads.

No other than annual assessment work has been done on the Topside and Reliance groups. However, the geologic features of the district are such that an extensive, and probably rich, ore body could be developed.

The Bonanza group which lies adjacent to the Headwaters on the east has good ground, although undeveloped.

One of the most promising properties in the district is that worked by Messrs. Probeck and Ebert on the "Inca" and associated claims. The "Inca" vein is about 21 meters wide and pans remarkably well. A one-stamp mill, for prospecting purposes only, has just been set up here.

The mining men of this district are preparing a petition to the government asking for a permanent district mine warden. The idea of mining wardens came from the Australian mining men who are located in the district, and I believe that the more Australian ideas we adopt here in mining, the better off we shall be. The Australian mining law to-day is perhaps the best in the world.

The division of mines has completed its report on the ore deposits of the district. The work was begun in 1906 by A. J. Eveland who made a topographic map and contributed notes on the geology of the district. This map has been revised and a fairly complete study of all the properties has been made.[1] The work has been done by Mr. F. T. Eddingfield, mining engineer, and the writer as geologist. The following facts seem to be fairly well established in regard to the ore deposits in the Benguet district:

(1) The ore deposits are intimately related to igneous intrusions. (2) Gold is found in quartz fissure veins in andesitic intrusions; (3) In calcite veins, probably not fissures, but in andesitic intrusions; (4) In contact zones between sedimentaries and andesitic intrusions. (5) Gold was deposited from ascending waters. (6) The gold is associated with pyrite and in one locality with tellurium. (7) The gold veins in many cases carry much manganese oxide. (8) The ores are only partly free-milling. (9) There has been some secondary enrichment. (10) The ore deposits are found in a region of great rainfall and steep slopes. (11) The zone of oxidation is shallow. (12) Although none of the mines has gone below water level, the indications are that many of the deposits will become richer with depth.

[1] This map and paper will appear shortly in the Philippine Journal of Science.

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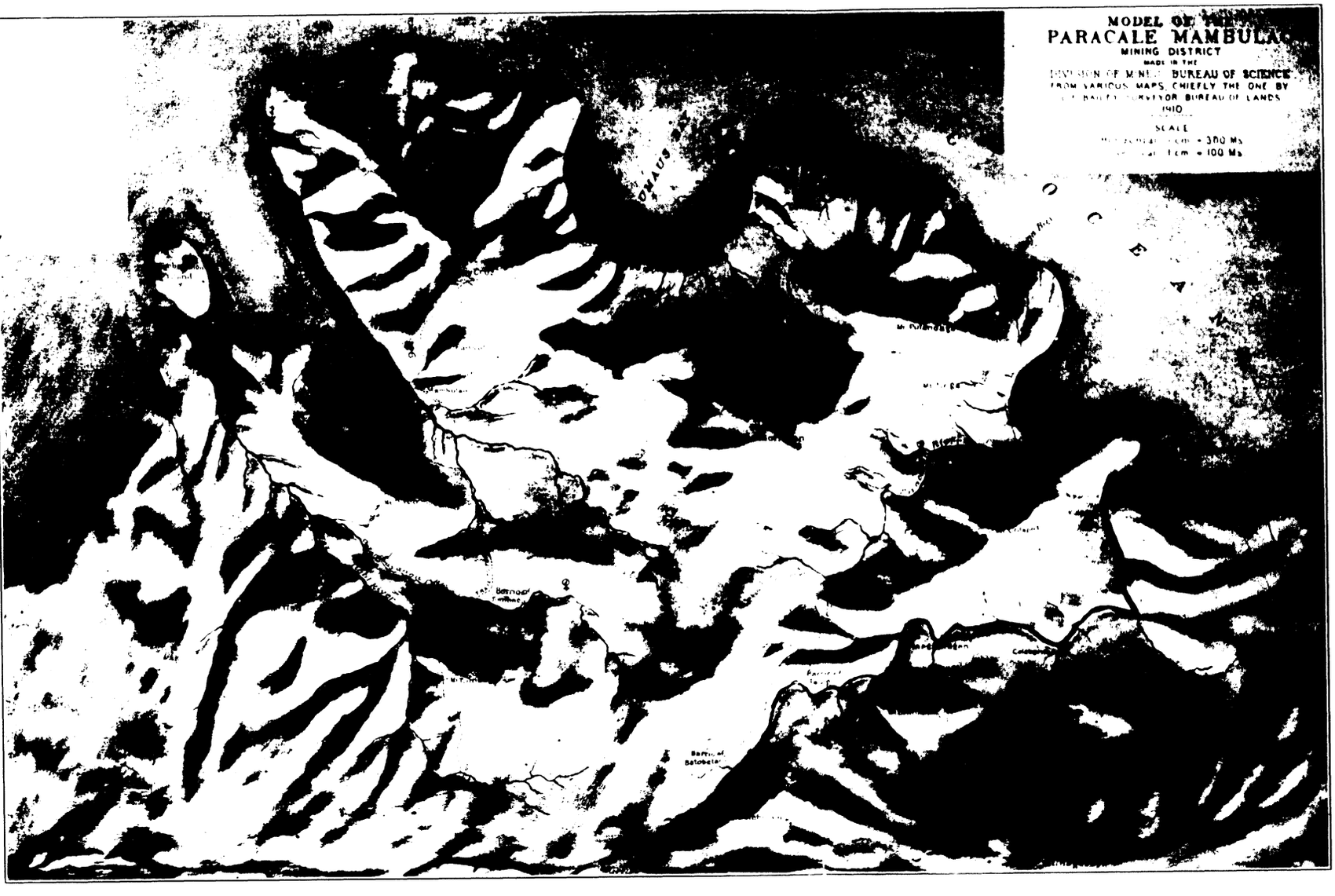

PLATE IV.

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The needs of this district are as follows:

(1) Capital. (2) A hydro-electric power plant on the Agno River to run mills of a large capacity. (3) More development work. (4) A mine warden. (5) A location tax. (6) Greater publicity.

The labor question in this district seems to be very favorable. When the Filipino becomes trained, he proves very satisfactory. The only trouble which arises is generally through lack of numbers. The Filipinos at present used in underground work are drawn from the rice fields of the lowlands.

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PARACALE-MAMBULAO MINING DISTRICT.

By PAUL R. FANNING.

Measured in terms of production, the mining industry in the Paracale-Mambulao district did not progress as much as was expected, and the output for 1910 shows an actual decrease from that of 1909; but measured in terms of future probabilities, the district is to-day in a more secure position than at any time in its history.

Gold production by years.[1]

[In pesos Philippine currency.]

1907	1908	1909	1910
4,000	152,270	216,701	171,900

A decrease of 44,801 pesos is to be noted between the production of 1909 and that of 1910. However, this retrogression is merely temporary and does not in any way mark the beginning of a decline. It can be attributed to the non-operation of the Paracale dredge for six months of the year during the construction of a new pontoon.

During the year the Stanley dredge contributed to the production, and the Philippine's dredge, San Mauricio and Tumbaga mines entered the field as producers.

Gold production by companies in pesos, Philippine currency 1910.

Paracale Gold Dredging Co.	69,855.00
San Mauricio Mining Co.	34,350.00
Stanley Gold Dredging Co.	41,000.00
Tumbaga Mining Co.	9,045.00
Heise Dredging Syndicate	17,650.00
Total	171,900.00

DREDGING.

The greatest confidence can be felt in future production from dredging, and the output of the district during the next few years will depend to a great extent upon this work.

[1] Some silver is alloyed with the gold.

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During the year greater attention was paid to the testing of placer ground, and several properties are now in a position to command capital for the purchase of a dredge. Among these can be named the Gumaus, the Paracale Extension, and the Philippine Gold Dredging Company.

THE PARACALE GOLD DREDGING COMPANY.

The Paracale dredge operated for six months and produced 69,855 pesos worth of bullion, or one-third of the output of the entire district. Early in January the dredge sank in shallow water owing to the decay of the pontoon under the attacks of the teredos which infest the waters. The machinery was easily salved, and construction of the new pontoon was begun at once. Hand-sawed native hardwoods were used and as a protection against the teredos a lining of felt and tar was placed between the inside and outside sheathing. A new 120 horsepower tubular boiler, a 60 horsepower compound engine with condenser, a 12-inch centrifugal pump and a new digging ladder and buckets were installed. Further, the screen was lengthened 5 feet and more table area was added to make a better saving of the gold. To complete the improvements, an electric lighting system was installed. The capacity of the buckets remains 4 cubic feet as formerly, but increased yardage is obtained by a bucket speed of twelve per minute instead of nine.

These improvements resulted in splendid yields of bullion, and from July to January the average production was close to 10,800 pesos per month. This dredge still has a large acreage of rich ground and its future yearly production should well exceed that of the past.

During the latter part of the year a mill was being constructed for the treatment of the rich quartz boulders brought up by the dredge. A Huntington mill and Wilfley table will be used, and as there are several thousand tons of boulders on the dump, a splendid yield should be obtained.[1]

THE STANLEY GOLD DREDGING COMPANY.

The Stanley dredge operated very irregularly during the year and produced 41,000 pesos worth of bullion. This is a very creditable showing for the ground, as the machinery is not only in bad shape, but the design of the dredge, lacking as it does a revolving screen and sufficient gold saving devices, renders it incapable of making a close saving of the gold.

THE PHILIPPINE GOLD DREDGING COMPANY.

The Philippine's dredge had proved itself too weak to handle the deeper material and during 1910 operated on its own ground for only a few hours. Early in the year the dredge was leased to the Heise Dredging Syndicate and later moved to the Malaguit River. The owners of this dredge are now in a fair way to receive a large return for their money, and it is quite probable that a new dredge will be bought, so constructed as to handle their own ground which is said to be of good value.

THE HEISE DREDGING SYNDICATE.

This Syndicate secured a lease on the Philippine's dredge and in August it began work on the Malaguit River. Various difficulties resulted in small returns for the first few months' work. The pay-channel was reached toward

[1] This mill is now reported to be saving 20 pesos per ton by amalgamation alone.

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the middle of December, and in the period from December 15 to January 1 excellent cleanups were obtained.[1]

THE PARACALE EXTENSION GOLD DREDGING COMPANY.

The Paracale Extension Gold Dredging Company came to grief through the inability to secure sufficient capital for the purchase of a dredge. It is understood that the ground has now reverted to the original owners, and it is expected that the money invested for stock will be returned. It is unfortunate that this enterprise was not successful as the tests made of the ground were stated to be exceptionally good and were said to average 1.05 pesos per cubic yard. The acreage and the ease with which this ground can be worked indicate that it will not be idle long.

THE PHILIPPINE EXPLORATION COMPANY.

The Philippine Exploration Company has an option on the Gumaus property which by double tests has been proved of exceptional merit. It is stated that out of a total dregeable area of about 75 hectares, 20 hectares contain such value that 2,490,532 pesos net can be gained. The ground averages about ₱1.04 per cubic yard with a depth varying from 8 to 20 meters. Capital is now being secured for the immediate purchase of a dredge.[2]

OTHER PROPERTIES.

Tests have been shown that many of the smaller properties are of sufficient value to warrant dredging. It is probable that their future to a great extent will depend upon consolidation with the larger interests. Several movements have begun already, but as yet no definite action has taken place.[3] During the year the Paracale Consolidated Placer and Mining Company was formed and some testing of their properties was carried on, but as yet no steps have been taken for the purchase of a dredge.

QUARTZ MINING.

THE SAN MAURICIO GOLD MINING COMPANY.

The San Mauricio Company operated its mill for some one hundred and eighty days at various times throughout the year and won some 34,350 pesos worth of bullion and concentrates. Extensive development work was carried on and a large body of ore was blocked out between the first and second levels. The operation of the mill exhausted the majority of the ore above the first level, but very little of the other ore was attacked. The irregular operation of the mill was due to machinery troubles, to insufficient water for mill purposes during the dry season, to an overabundance of water in the mine during the wet season, and to the inability to secure sufficient fuel. These difficulties could easily be remedied. In December the mine was indefinitely shut down, owing to the inability to secure capital to carry on operations, the inability of the mill to make better than a 40 per cent saving and various other complications.

[1] This dredge has averaged close to 7,200 pesos per month during the period from January to May, 1911.

[2] Construction of the dredge is now under way.

[3] Consolidation has just been effected between the Paracale Gold Dredging Co., the Philippine Gold Dredging Co., and various other properties on the Paracale Rivers.

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THE TUMBAGA GOLD MINING COMPANY.

The Tumbaga mine continued its shaft to the 200-foot level and cross-cut to meet the vein. It is understood that the vein was not met, and as indicated by the winzes from the first level, the probability is that the stringers have pinched or faulted. However, in the upper workings a pocket of extraordinary ore was discovered which by smelter returns gave 9,045 pesos on a shipment of 2.5 tons.[1]

THE NAVOTAS GROUP.

The Navotas property came into prominence by the discovery of some rich surface specimens containing visible gold. Capital was secured and a hoisting plant was installed. A shaft was sunk 30 meters and a cross-cut run to meet the vein, but as the mine is now indefinitely shut down, it is probable that the vein met did not come up to expectations.

OTHER PROPERTIES.

A considerable amount of prospecting was done on various properties in the district, but the ore opened up was of medium or low grade value which would require for its development sums of money quite beyond the means of the prospector.

In view of the series of failures which has beset the mining industry in this district since the earliest Spanish days, it may be advisable here to consider the salient features of the geology, ore-deposits, and metallurgy, with the aim of indicating the future lines of development.

GEOLOGY.

The main formations are: a diorite schist, a granite-gneiss, and sedimentaries.

The diorite schist is found bordering the granite-gneiss practically in all directions and represents the old land mass into which the granite was intruded and later around which the sedimentaries were deposited. In composition the schist is quite variable.[2] The age of the formation is probably Pre-Tertiary.

The granite-gneiss is developed in semi-elliptical shape from Mambulao to Paracale and appears to be of batholithic nature. The intrusion of the granite produced a profound metamorphism of the diorite which at the contacts is much broken up, sheared and saturated with granite constituents. During the cooling of the granite, large silicious lenses were formed which, however, are not gold-bearing. The age of the formation is probably Pre-Tertiary or early Tertiary.

The sedimentaries are found southward from Mambulao; they strike about N. 10° W. and dip about 70° to the southwest. Slate, sandstone,

[1] At this date the mine has indefinitely shut down.

[2] Iddings, Joseph P., *Philip. Jour. Sci., Sec. A* (1910), 5, 155; Smith, Warren D., *Min. Resources P. I. Bur. Sci. Div. Min.* (1910).

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and conglomerate are present, and all bear evidence of extensive metamorphism. The age of the formation is probably Miocene.

Toward the end of the Tertiary an orogenic movement took place which uplifted the region, sheared the diorite to a schist, sheared the granite to a gneiss and acutely folded and metamorphosed the sedimentaries. Contemporaneous with or just subsequent to this movement, basalt and andesite were intruded in the rocks and as a later phase, vein ore-deposits were formed. Extensive erosion has exposed the granite-gneiss, and the gold from the veins has concentrated in the alluvial gravels. A recent subsidence has taken place, and the auriferous gravels are now slightly buried.

ECONOMIC GEOLOGY.

PAST HISTORY.

The history of this district is marked by the rise, culmination, and decline of several periods of activity. Previous to the Spanish occupation in the 16th century the main source of the production was from the rich, shallow placers where the gold could easily be saved by panning. With the discovery of gold by Don Juan Salcedo in 1572 more attention was given to the lodes which on the surface possessed some remarkably rich values. The first method of extraction was by fine-grinding the ore on stones and panning the liberated gold. Later, the introduction of the arrastre greatly increased the scope of operations, and it is probable that the annual production reported in 1609 of 400,000 pesos was almost wholly due to this newer method of treatment. During this period the region must have been the scene of the greatest activity, as witnessed to-day by the great number of open cuts and shafts on the outcrops of the veins and tunnels run at shallow depths below.

With a depth of 10 to 12 meters, the soft, oxidized ore changed to a hard, sulphide ore, which being only slightly free-milling soon stopped operations. Further, inability to handle water caused shut-downs even when pay ore was still exposed at the bottom. The period of driving tunnels to drain the ground then began, but in the majority of cases these tunnels gave only a very few feet more depth. The difficulty of running in hard country rock without explosives or steel, and the further difficulty of a hard, refractory ore, resulted in small production subsequent to the period of tunnel development. The district declined until in 1876 the production was only some 7,200 pesos per year. However, the knowledge of the existence of rich ores attracted the attention of persons outside the Islands, and in 1893 the Philippine Mineral Syndicate was formed in London for the purpose of opening up the district and installing more modern methods of ore treatment. However, the methods in vogue at that time were such as to preclude the possibility of economic saving, and after the spending of a considerable amount of money in the surface development of the ores and in the construction of mills predestined to failure, the company was forced to withdraw.

The occupation of the Islands by the Americans in 1898 inaugurated the present and fourth period of activity, which by virtue of the placers is obviously destined to succeed. The quartz mining can not yet be said to have come into its own, but the potential possibilities are to-day greater than ever before.

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THE ORES.

The gold-silver ores are of the usual quartz type containing pyrite as the chief sulphide. Some copper is generally present. Quite frequently galena, sphalerite, chalcopyrite, pyrrhotite, magnetite, and the various oxidized derivatives are seen. Lead chromate occasionally occurs at the San Mauricio mine, and native copper has been reported from some veins near Paracale. Manganese and arsenic are infrequent, and tellurides have been reported from the Tumbaga only. The quartz is generally hard and massive, but with oxidation a cellular structure is developed due to the leaching out of the sulphides. The gold occurs to some extent free, especially in the oxidized ore, but in general it is in the sulphides. The original association with galena is frequently very marked, and the secondary association with secondary copper is quite general. At the Tumbaga mine some primary gold occurs not only in the sulphides, particularly galena, but also visibly in the calcite and quartz. The quartz boulders brought up by the Paracale dredge often contain primary visible gold disseminated in the interstices between the quartz crystals. Silver is inconspicuous, although at the San Mauricio a pocket of 75-ounce silver-galena ore was discovered on the second level. The silver as a rule seems to bear some ratio to the gold, for large gold assays generally give a better silver value.

The average ore for the district is very low grade but the immense amount of such ore is a noteworthy feature. A great variation in values is found even with close sampling. Horizontally and vertically the veins show great assay changes, and the utmost care must be used in approximating an average value. Rich surface ores are of not infrequent occurrence, and visible gold occasionally is present.

The veins generally fill well-defined fissures which strike about N. 10° E. and show, in the granite-gneiss, a remarkable parallelism. The dip is generally about 70° to the southeast, although occasionally some wide variations occur. Veins are found up to a width of 10 meters but the average is less than 1.5 meters. Many veins are broken up, and branch out near the surface, but with depth are better defined. The walls are generally clean cut, but occasionally silicification of the country rock is noted. Pyrite is often disseminated outward from the vein, but usually carries exceedingly low values.

The influence of the country rock is very marked. Under the forces which produced the fissures, the schist broke very irregularly as if shattered, while the granite-gneiss broke in well defined fissures. In passing upward from the gneiss to overlying schist the fissure toward the contact begins to split into branches which in passing through the schist often may fold over or disappear as stringers. Generally

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where a vein passes horizontally into the schist it will thin out soon into a stringer and disappear.

True contact veins between the schist and granite-gneiss are either absent or very rare. This is obvious, as the veins generally are fairly vertical, while the true contact between the gneiss and schist as shown in the San Mauricio Mine is moderately horizontal.

Secondary enrichment plays a most important part in the economics of the ore. Most of the ore as originally deposited was quite low grade, and where it is exposed, either on the outcrop or in depth, the values generally are so small as to preclude the possibility of mining. Under the action of descending superficial waters, the gold and copper out of the portions of the vein now eroded away have been carried downward to enrich the ore below. The channels of these waters generally were the foot or hanging wall and are characterized by oxidized ore heavily stained with iron, by clay gauge in which secondary pyrite often occurs, by copper minerals, and by gold values in excess of the quartz which lies more toward the center of the vein. The lower limit of the enrichment along the walls is in the main close to the ground-water level, yet some gold enrichment was noted at the San Mauricio, 25 meters below this level. In general, the copper and gold increase to the ground-water level; but below this level the copper rapidly decreases to mere traces and the gold also shows a marked tendency to decrease.

GENESIS.

The uplift of the region was accompanied by the intrusion of basalt and andesite. By continued stress, fissures were formed which often followed the dikes as special lines of weakness. Hot, mineral-bearing solutions from below probably genetically related to the intrusions, then filled the fissures and precipitated their burden to the formation of ore bodies. Subsequently, secondary enrichment has increased the values and given shoots of more profitable ore.

TREATMENT OF THE ORES.

The 10-stamp Longos Point mill relied upon amalgamation alone to save the values. The ore was refractory and probably less than a 20 per cent saving was made. The 20-stamp San Mauricio mill used amalgamation and concentration on Traylor tables, but the extraction was seldom above 40 per cent. The Tumbaga ore was unique in its free-milling quality, and the Huntington mill and vanners would probably have made a good saving. The quartz boulders brought up by the Paracale dredge are fairly well adapted to amalgamation and concentration, so that the mill installed (a Huntington mill and Wilfley table) will probably make a good saving.

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Because of the lack of developed ores, it is as yet impossible to state definitely what treatment will give the best results. Owing to the nature of the ore, its variations in value and in mineralogy, each mine must make elaborate tests to determine the process which it will adopt.

Most of the ores of the district are of too small value to permit shipping to smelters. Further, the indications are that the ores generally are refractory to amalgamation and concentration. Many of the surface ores contain so much copper as to prevent successful cyaniding. The probability is that with depth many such ores will possess little or no copper and so will become adapted to cyanide treatment. Tests made by the writer indicate that fine grinding, possibly combined with slime concentration, and air-agitation in cyanide solution will give an excellent extraction.

MINING CONDITIONS.

In general the mining conditions are fairly good, although special precautions must be taken to insure a constant supply of fuel; to have adequate pumps for the extra mine-water during the rainy season; to measure streams during the dry season for sufficient water for mill purposes; and to attract native labor by proper treatment.

FUTURE DEVELOPMENT.

The irregular nature of the ore requires extensive development before a process of treatment can fully be determined. In particular it is essential that the ores should be developed well below the ground-water level, which in many cases means below sea level. Tunnels as a rule give very shallow depths in comparison with their length, so shaft work generally will be necessary.

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THE NALASVETAN, AMBOS CAMARINES, GOLD DISTRICT.

By WALLACE E. PRATT.

Location.—Nalasvetan, a *barrio* of Labo, Ambos Camarines, is situated on a branch of the Bosigon River (also called the Labo River) and is about 21 kilometers in an air line southwest of Mambulao. It can be reached from Mambulao by means of a very poor trail.

History.—Nalasvetan was the site of a considerable amount of early mining. The ruins of the few underground workings in this place, perhaps, are more extensive than any others in the Camarines gold field. There is no record of extensive Spanish mining at Nalasvetan, and the caved excavations have been attributed to Chinese miners working at a time earlier than the Spanish occupation. No direct evidence supports this supposition.

Geologic.—The district lies at the center of the great area of extrusive and intrusive rocks which form the cordillera in this portion of Luzon. The prevailing type is porphyritic andesite, black in color grading into basalt and occurring generally as volcanic agglomerate or breccia. In the streams, boulders of diorite are not unusual, showing that the older, coarsely crystalline rocks, with which gold is commonly associated in the Philippines, occur here also, but no exposure in place could be found in the immediate vicinity. Isolated patches of metamorphosed sedimentary (Tertiary?) rocks were observed also at several places along the trail from Mambulao to Nalasvetan. Evidently, before the advent of the volcanics, this was an area of older crystalline rocks, at least partly covered with sedimentaries.

Ore body.—The gold-bearing deposit at Nalasvetan can scarcely be termed a vein in the strict sense of that term. Mineralization, which has been accompanied by intense silicification, has occurred along the axis of a narrow ridge bearing N. 30° W. The original rocks of this ridge appear to have been andesite, but almost complete replacement by silica has resulted in a medium-hard, iron-stained, siliceous felsite, grading into quartz and jasper. The gold bearing formation is not clearly defined and the values (entirely free gold apparently) are irregularly distributed. As developed by the old workings already mentioned, the ore body is several hundred meters long and varies in width up to

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15 meters. Irregular pockets of iron-stained, clayey material, in which free gold is often visible occur throughout this zone. The felsite and some of the quartz are also gold-bearing. The ore is completely oxidized and shows coloring from the oxides of manganese as well as iron.

Development.—The old workings at Nalasvetan form an open cut about 500 meters long and from 5 to 15 meters in width. The depth varies, averaging, perhaps, only 5 meters, the original cut having been largely filled with debris, but occasional irregular shafts or "gopher holes" go down to greater depths.

Recent development consists of four short tunnels approaching the ore at different elevations, only one of which reaches the mineralized zone. This work has been done by the Nalasvetan States Mining Company, the claims of which cover the whole ore body. This company has leased the property to Mr. Boag, one of the partners, and at present a 3.5-foot Huntington mill is being installed. The Neal tunnel which cuts the ore body will be extended into the ore, the material taken out will be crushed, and the values saved by amalgamation. This plan should result in further preliminary development without cost to the company.

Nalasvetan has available water power and abundant timber for mining purposes, or for fuel if desired. The elevation (something over 300 meters), and the deeply incised drainage system permit of mining the ore from adits above the mean level of ground water. These conditions eliminate expensive mine pumping and hoisting. The ore is apparently entirely free-milling, making extraction cheap and simple. On the other hand, the district is difficult of access, since the nearest port where boats touch at present is Mambulao and outside communication is a very serious problem.

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NOTES ON THE MINERAL RESOURCES OF CATANDUANES ISLAND.

By WALLACE E. PRATT.

LOCATION.

Catanduanes Island, a subprovince of Albay, lies off the east coast of south-eastern Luzon. It is separated by narrow straits from Caramuan Peninsula, Ambos Camarines, and is three days distant from Manila by steamer.

There has been no mining and very little prospecting in Catanduanes since American occupation, and little is known of its resources. Spaniards indulged in desultory mining for gold and coal at several places, late in the Spanish régime.

GEOLOGY.

General.—Geologically, Catanduanes is closely related to Caramuan Peninsula, an area of Tertiary sedimentaries more or less disturbed and metamorphosed and lying on the flanks of a probably intrusive cordillera. Recent coralline limestone covers the earlier formations around a considerable part of the coast of Catanduanes. The mountain range trends in general north and south, with a spur to the northeast. The highest elevations (about 900 meters) are in the southern part of the range. The prevailing rocks in the cordillera seem to be andesites and related porphyritic type. The location of the sedimentaries in Catanduanes is known only as it is inferred from the reported occurrence of coal.

Economic.—The principal economic mineral deposits occurring in Catanduanes are gold and coal. Copper has been reported, but its existence has not been verified.

Gold.—Gold is known to occur in placer deposits along the Pajo River which reaches the coast at the extreme southern end of the island, and along the Oco, and other smaller rivers in northeastern Catanduanes. The rivers in both these districts rise in the cordillera, whence undoubtedly all the gold came originally. No lode deposits are known. The northeastern part of Catanduanes has not been studied by the di-

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vision of mines of the Bureau of Science, but some information has been obtained concerning the Pajo River placers.

The Pajo River, emerging from its cañon in the mountains, flows across a narrow coastal plain of raised coral reefs, and enters the sea near the town of Virac. Over these coral reefs, it has spread an alluvial fan of igneous gravel brought from the mountains. The gradual elevation of the reefs probably continues at the present time and during the process, the older, higher portion of this gravel deposit has been moved down again into the river channel by the lateral drainage, and transported farther toward the sea, leaving the older coral reefs practically bare. However, the gold (or at least a part of the gold) which came down from the mountains with the gravel, owing to its great specific gravity, has been left behind during the working over of the gravel, and is now found in the shallow clay covering the coral reefs. The clay covering results from the weathering of the coral itself and is nowhere more than 2 meters deep. It is a stiff, plastic clay and holds the gold tenaciously. This rather unusual condition of gold occurring in coral, has led prospectors to request assays of coralline limestone for gold values.

The gold occurs in rather coarse, smooth flakes, always flat and well worn. There is no question of its having been transported some distance by water. Owing to the scanty clay covering on the limestone reefs, the gold is very conspicuous. After rains the natives pan over the rivulets which cross the ground, sometimes winning as much as a peso in a day's work. However, test holes over a considerable area indicate that the reefs are not rich. They appear in places to be rich because specks of gold may be seen on the surface of the ground. In reality, the few specks that are visible constitute all the gold occurring in that area; consequently the value per cubic meter is low.

The occurrence of gold over the raised portions of the river valley suggests a probability of finding values in the present river channel. Of course it must be recognized that old river courses in alluvial gold deposits are richer as a rule than recent channels. However, in the present instance, it is evident that the change in position of the river channel has been due to a gradual and apparently continuous lateral shifting, caused by the elevation of the land area. Every vestige of the gravel wash which must have covered the raised ground has been removed, leaving the coral quite bare. Probably some of the gold originally deposited over the old water courses was taken away along with the gravel to the present channel. It is known that the coral reef deposits are richer as the river which crosses them is approached. Owing to the coarse gravel and boulders which fill the river channel it is almost impossible to reach the underlying limestone with the usual type of test-

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ing device. To obtain reliable tests, it would be necessary to put down small shafts to bed rock, an undertaking which in turn would involve a considerable amount of pumping. The surface gravel in the river shows smaller values than the adjacent coral reefs, but considering the coarse, clean character of the gravel, values would not be expected except just above bed rock.

The Pajo River is accessible, is large enough to float a small dredge, and in view of the foregoing observations seems to merit thorough testing for placer ground.

The Spaniards are said to have mined gold in the foot-hills near where the Pajo River comes out of the mountains. The place was visited, but only a caved shaft remains of the workings. The country rock is basalt, unmineralized, and carrying only small stringers of barren quartz.

Coal.—Coal occurs on the western coast of Catanduanes, and it is stated that formerly ships passing through the Maqueda Straits took on coal which the natives mined and brought down to the shore. Recently two Japanese, leaving the East Batan Coal Company, came to Catanduanes, and started mining on their own account near the coast, south of Caramoran.

Coal is reported also from Bato on the southern coast. Nothing is known of the position or thickness of the beds nor the quality of the coal as compared with other Philippine coals.

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MINERAL RESOURCES OF NORTHWESTERN PANGASINAN, LUZON.[1]

By PAUL R. FANNING.

A geological reconnaissance has recently been made of northwestern Pangasinan, Luzon. The area covered comprises about 750 square kilometers and the essential features of the geology were determined especially with reference to the occurrence of metallic ore-deposits, coal, and oil.

Some recent prospecting has been carried on, but there is no evidence of old, native workings, a feature which in the Philippines generally means the absence of valuable ore-deposits. The reported ocurrence of gold, silver, copper, zinc, lead, antimony, and manganese has been confirmed, but it seems that the deposits are of no commercial value. Auriferous placers of value appear to be absent. The reported existence of tin, mercury, cobalt, and nickel has not ben confirmed, although future work may yet prove their presence. Positive evidence of coal or oil was not seen, although the sedimentary formation is such as to permit of the occurrence of either. The general conclusions are that the surface indications are adverse to the occurrence of economic deposits of the valuable metals, but that there is a possibility of oil, even though the evidence as to its existence was completely negative.

The sedimentaries consist mainly of limestone with some sandstone and shale. The general structure is gently monoclinal, and no evidence of shattering or extensive faulting was seen. The area which appears to be best adapted to the accumulation of oil extends from Anda on the north to Balincaguin on the south, and from west of Bani to Alaminos on the east. Much of this land is open to placer-oil location, and the ground owned by natives can be leased for small sums of money. Artesian wells are soon to be sunk at Anda, Bani, and Alaminos, which will possibly prove the existence of oil.

[1] A detailed account of the mineral resources of northwestern Pangasinan will appear in the Philippine Journal of Science.

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PANGASINAN PLACER.

By F. T. EDDINGFIELD.

Near the boundary line between Benguet and Pangasinan the rugged mountains of Benguet change abruptly to a flat plain. This plain has been the depository for all the wash carried by the mountain streams which tap the mineral districts of Benguet. The Baguio mineral district is drained by Antamok Creek, Gold Creek, and Batwaan Creek, which flow into the Agno. The Agno flows in a constantly changing, meandering course over the plain, depositing whatever gold it carries over a large area. Farther west the Tuboy taps the mineral district of Lubang in lower Benguet. During heavy rains these rivers overflow their banks and cover large tracts of land, depositing "flood gold." It is at this time that the natives pan the gravels for gold and are able to recover considerable amounts. The best pannings are said to come from the Tuboy.

A few months ago an attempt was made to drive test holes with a 3-inch pipe near the Agno but this was not satisfactory on account of the large number of boulders and the great depth to bed rock. One or two holes were driven for a distance of 18 meters, but only a part of the sand was recovered, consequently they were worthless as test holes.

Pannings were made of the sands near the surface, along the streams and from exposed banks along the road from Asingan to Tayug. Every pan showed a number of "colors." These colors were saved and weighed, and the results showed an average of 16 centavos per cubic meter for the surface gravels. This gold was undoubtedly derived from the Baguio mineral district. It was light yellow, and occurred in light round flakes.

The surface showing is promising enough to warrant further testing with a larger, more suitable drill.

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OTHER MINERAL DISTRICTS.

By F. T. EDDINGFIELD.

MANCAYAN—SUYOC.

This district was discussed in the Mineral Resources for 1909. The conditions remain about the same. The claims are still being held, and are being slowly prospected, awaiting a more favorable time for mining. A large amount of gold was recovered by the natives from washing gravels and by surface mining. The total amount for the year 1910 was estimated by one of the miners in Suyoc at 60,000 pesos.

LUBANG DISTRICT, LOWER BENGUET.

This district has attracted but little attention, although it was one of the first to be prospected after the American occupation. The formation is similar to that of the Baguio district, and the ore bodies present the same general characteristics, with the exception that less manganese is present. Good pannings are found along the entire length of the river which drains the distirct, and it is reported that very coarse gold is recovered by the natives after each rain storm.

At the present time the only men actively employed are Messrs. McMichaels, Lambert, and Mentzer, who were the first to discover the location of the ore bodies. They have prospected several strong leads that show some promise. Messrs. McMichaels and Lambert purchased a 3.5-foot Huntington mill and hope to have it operating in the near future.

NUEVA ECIJA.

It is reported that one dredge has been purchased to place on a property in eastern Nueva Ecija, and that in the near future another will be placed either in Nueva Ecija or just across the mountains in Tayabas. Several tests have been made in this district with a 3.5-inch drive pipe, and ground averaging 1 peso has been reported. A considerable amount of gold is yearly panned by natives, and sold in small lots to Chinamen and also to Americans.

One miner, Mr. R. J. Sharp, operated a 60-foot sluice with Hungarian riffles for four months and recovered 1,368 pesos. Mr. August Johnson reports the discovery and location of a mineral vein, across Mount Baca and Macbala Creek, which also crosses the Cabu, striking NE. and SW. From all indications there should be several good quartz properties in this range of mountains.

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MARINDUQUE.

Several years ago Maurice Goodman of the division of mines wrote a report on the geology and ore deposits of Marinduque, yet the district has excited but little discussion. However, an English company took up some property about 20 kilometers south of Santa Cruz and recently installed a 3-stamp mill with concentration tables. A lead, copper, zinc ore with free gold is being milled. It is reported to average 25 dollars per ton in gold.

MINDORO.

Several persons have been exploring Mindoro for placer, and very favorable accounts come in. There is some sluicing and dredging ground, but a large part of the placer is very deep. The climate in the mineral districts is reported to be disagreeable and malaria to be prevalent.

SAMAR.

Mineral veins of both copper and gold are reported in Samar. There is a tale about a rich gold mine on this island, but as yet no American has found it. However, the natives very frequently bring in gold.

MINDANAO.

CANSURAN DISTRICT.

The Cansuran mineral district is located a few kilometers from Surigao.

The principal locators are Mr. E. O. Parker, and Mr. Briggs. They have obtained the title to an old Spanish grant and have located the ground surrounding it. The nuggets brought in by Mr. Parker are the largest ever seen in quantity in the Philippine Islands and remind one of the old days in California or Alaska. He reports plenty of water from the Tugunaan River and large tracts of sluicing ground. He stated further that a few natives took out over 2,000 pesos worth of gold in a few days on a portion of this property.

PLACER DISTRICT.

The gold in this locality is finer than in the Cansuran district, but it is said that the properties are very promising. Two American miners worked here for a time several years ago, but suspended operations because of unfavorable conditions.

BUTUAN DISTRICT.

Several claims have been located by two miners, Mortimer and McCartney, on a branch of the Agusan River. They have recently formed a company to develop the ground. They believe they have found the old bed of the river which is very rich. A sample of the placer gold brought in by Mr. McCartney showed coarse and fine gold, but the average was much coarser than any gold so far discovered, except that in Cansuran. It is reported to be in a shallow bed of gravel which can be sluiced with little difficulty. Captain Wilson has also been prospecting a little farther to the south.

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PIGTAO DISTRICT.

This district has recently attracted much attention, partly because of the publication of a translation of a report by Enrique Abella appearing in the Mineral Resources for 1909. Quite recently a party was sent to test the ground, preparatory to building a dredge.

Mindanao should become very prominent in mining in the near future. Such coarse gold as is brought from there is enough to excite even the skeptic to enthusiasm. Mr. Parker said that he himself bought 10,000 pesos worth of gold from the natives of Surigao and estimated that fully 20,000 pesos worth was taken in Surigao in 1910. It is very probable that a like amount was obtained from the other districts, so that Mindanao produced about 40,000 pesos worth in 1910.

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OTHER METALLIC MINERALS.

By F. T. EDDINGFIELD.

This general subject was discussed in the 1909 Mineral Resources by Henry G. Ferguson whose article covers the ground as it is to-day, for but little exploitation has been carried on since in regard to any but gold bearing ores. However, it is interesting to know that some placer samples were brought to the Bureau of Science containing a value of about 1.20 pesos per cubic yard in platinum alone. For many years it has been known that platinum existed in the Philippines, but such values have never before been encountered. The grains were all rounded and water-worn as if they had traveled several miles. Previously, some grains were found as large as the little finger nail. All evidence points to the fact that the platinum originated in the mountains in the eastern part of Nueva Ecija or Bulacan, or both.

A further interesting discovery of the year 1910 was the presence of cinnabar in two different places at Benguet. One deposit was directly on the Kias trail at a point south of the Tejon dyke. It occurred as beautiful, blood-red crystals in a rusty quartz vein about half a meter wide. Each pan of rock contained from 15 to 20 crystals, but no gold was found at this point. The other deposit was south of Batwaan Creek, but here it was associated with gold.

A copper deposit is reported near the headwaters of the Bued River, which was said to be very promising. It is a rather flat vein of copper silicate, about 1.5 to 2 meters thick. Very little prospecting has been done on the vein, but it deserves more attention than it has attracted. Most of the veins in the Bued River Valley are high in copper. One property had ore in the oxidized zone, carrying 15 to 20 per cent of copper and about 100 pesos in gold.

Tin has often been reported in various districts, but so far no authentic samples have been found, and no formation suitable for tin deposition discovered.

Zinc has also been sought in the Islands, but no paying deposits have been discovered, although this metal is of common occurrence associated with lead, in many gold bearing veins in Benguet, Ambos Camarines, Masbate, and Cebu.

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THE COAL RESOURCES OF THE PHILIPPINE ISLANDS.

By WARREN D. SMITH.

INTRODUCTION.

In 1910 the production of coal in the Philippine Islands was nearly 27,000 metric tons, with a value of 200,000 pesos. From the above tonnage, 18,100 tons entered the market in competition with imported coal. The balance was used at the mine for steam. This output had no appreciable effect on the general market.

While the above figures show a slight decrease from the production of 30,366 tons in 1909, this fact can easily be accounted for by the decrease of activities at the United States Army mine at Liguan, Batan Island.

The imported coal was 377,355 metric tons with a value of 2,478,284 pesos. The greater part came from Australia and Japan.

Statement of the importations of coal into the Philippine Islands, by ports and countries for the calendar year 1910.[a]

[In pesos Philippine currency.[b]]

Countries.	Manila.		Iloilo.		Cebu.	
	Metric tons.[c]	Value.[b]	Metric tons.	Value.	Metric tons.	Value.
British East Indies	19,749	118,962	6,523	40,048	2,184	17,078
Dutch East Indies						
China	109	1,106				
Japan	144,337	1,121,582	5,010	47,606	8,489	84,570
Australia	136,576	690,990	18,438	93,926	21,876	127,682
Total	300,771	1,932,640	29,971	182,180	32,549	125,330

Countries.	Zamboanga.		Jolo.		Totals.	
	Metric tons.	Value.	Metric tons.	Value.	Metric tons.	Value.
British East Indies	2,261	12,416	10	90	30,727	185,194
Dutch East Indies	1,295	8,676			1,295	8,676
China					109	1,106
Japan	6,951	77,460	3,547	39,492	168,334	1,370,710
Australia					176,890	912,598
Total	10,507	98,552	3,557	39,582	377,355	2,478,284

[a] Figures furnished by Bureau of Customs.
[b] 1 peso = 50 cents United States currency.
[c] 1 metric ton = .948 long ton or 1.102 short tons.

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IMPORTANCE OF A COAL SUPPLY IN THE ISLANDS.

Consumption of coal is increasing yearly as new railroads are completed, new industrial plants installed, and as both foreign and inter-island commerce advances under the impetus of all new developments in the Islands. Several hundred steamers call at the various ports each year and coal in foreign harbors, or with foreign high-priced fuel of a grade not much better than the best coal found in the Islands.

Before 1909 practically all the coal used in the Philippine Islands came from Japan and Australia, consumers having to pay from 8 to 15 pesos and at times more, per ton, prices due largely to high freights and duty.

Markets.—The present annual consumption of coal is nearly 400,000 tons and nearly all of this is imported. Within the next few years this should increase to about 600,000 tons. As many steamers leave the Islands for the Pacific coast of the United States and southern China in ballast these markets may be opened on account of cheap freight rates.

There is good reason to believe that extensive iron deposits exist in the Philippines which can not be smelted satisfactorily without a good supply of coke, and when they are developed a further demand for coal will arise.

The Hongay Coal Mine in Indo-China, and the following five mines in Borneo, namely, two collieries in Sarawak, one at Labuan, one at Cowie Harbor, British North Borneo, and one at Pulo Laut, Dutch Borneo, will appear as competitors when development occurs, if we leave out of account Australia and Japan, and India, which countries are now delivering foreign coal to the Philippine market.

Four of these mines deliver a very good grade of coal which can be sold in Manila for a price lower than that for which an equal grade of coal has been produced so far in the Philippines. The Pulo Laut mine has a daily output of 500 tons, and it is located in the Macassar Straits, an important sailing route.

Any company in the Philippines must work against the handicap of beginning operations after these companies have been in operation sometime, and also they must consider the geographic factor, which involves such items as transportation, storage charges, increased handling, etc. This factor would be serious in the case of a property on a bad coast and off the track of steamers.

HISTORY OF COAL MINING IN THE PHILIPPINES.

The history of coal mining in these Islands dates from the year 1842, when the Spanish governor of Albay Province, Juan Velarde, worked and shipped coal from the vicinity of Calanaga Bay, Batan Island. The first recorded discovery of coal by the Spaniards, was as early as 1827, on the Island of Cebu.

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Not much serious work was accomplished until 1890. At that time active operations were begun on both Batan and Cebu, but with poor results, according to Enrique Abella y Casariego, at that time the Senior Inspector of Mines. The engineering was crude and the management of business details even worse. Too much money was spent on the plant before exploration had justified it.

In 1896 insurrection broke out and in 1898 the American occupation took place, and then followed several years of desultory disturbances which made it entirely out of the question to resume any industrial undertaking outside the coast towns. Many of the prospectors and small mining concerns which did venture into the hills came to grief.

In 1903 the United States Army began exploration on the western end of Batan, with the work in charge of Captain H. L. Wigmore, Corps of Engineers. Besides the government operations, another property has been opened on the eastern end of Batan and it is from this that practically all the Philippine coal now comes. In 1907 private concerns began work on and near the old Compostela properties in Cebu, but to the present time only exploration work has been accomplished.

Exploration and feeble attempts at mining have from time to time been made in Masbate, Mindoro, Samar, Negros, and Mindanao.

Coal occurs on a great many of the islands of the Archipelago, both large and small. The general map (Pl. II) gives the principal localities together with the completed and projected railroads.

GEOLOGY.

The geology of the Philippine coal fields may best be outlined by giving the stratigraphic column as it has been worked out in Cebu. This, it must be understood, is subject to future modification in part, as little more than reconnaissance work has been done anywhere in the Archipelago.

The geologic structure of the Philippine Islands is such as to introduce many difficulties into the profitable exploitation of the coal fields, yet these difficulties are not insuperable. Everywhere, the strata are folded and faulted, and in many places shattered by earthquakes. Landslides are of frequent occurrence, because of steep slopes and excessive rainfall. The roofs of the seams are rarely found to be firm enough to stand without timbering. The geology is similar in many respects to that of the neighboring islands of Formosa, Borneo, Java, and Japan.

Stratigraphic column of Danao-Compostela coal field.

Recent.	Alluvial deposits in streams and extensive and thick talus on all slopes; travertine in streams.
Unconformity.	
Pliocene and Miocene.	Upper white limestone, coralline, containing *Orbitoides, Lithothamnium,* and many mollusca in its basal portion.

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Unconformity.	Extrusive rocks, chiefly andesite. Terrestrial or Piedmont deposits consisting largely of conglomerate much oxidized.
Oligocene.	Shaley limestone and marl, cream-colored and soft; unfossiliferous save in the lower marly portion.
Lower Miocene or Oligocene.	Coarse gray sandstone. Coal measure shales with (4) coal seams.
Unconformity.	
Pre-Tertiary.	Basal Diorite and basal conglomerate.

The age of the deposits is either late Eocene or early Miocene. The limestone immediately overlying the Coal Measures as a rule contains fossils, and of the many forms two are well known and are characteristic "zone fossils." They are: *Lepidocyclina (Orbitoides) insulanatalis* Chap., a foraminifer with a wide distribution in the Indo-Australian region, and *Lithothamnium ramossissimum* Reuss, an alga, also widely distributed. These two mark the Middle Miocene. This is about equivalent to the Helvetian-Tortonian stage in the European column.

THE PRINCIPAL COAL DEPOSITS.

BATAN ISLAND.

Batan Island is 20 kilometers, almost due east, from Legaspi, in the Province of Albay, which in turn is a part of the long, irregular arm of southeastern Luzon. The island is from 16 to 20 kilometers in length and from 8 to 10 in width. It has an irregular coast line and is for its small size quite mountainous, one peak attaining an elevation of approximately 458 meters.

The formations are as follows: An igneous base of diorite, some serpentinized intrusives, the remnant of an iron formation, coal measures, including shales, sandstone and coal seams and at least two horizons of limestone. The upper one is to a great extent coralline. In fact, a coralline limestone very probably covered the entire island at an earlier time. The coal beds are inclined at various angles, often steep and in some cases vertical. At the points where they can be most easily reached from the seashore (and it would not be feasible to do much in the interior of this island) the beds unfortunately dip into the island, thus necessitating hoisting and pumping. There are at least two good seams of over 1.5 meters, and one or two more of uncertain thickness, in the western part which easily can be reached almost at sea level. On the eastern end of the island only one commercial seam has been opened.

East Batan coal mines.—With the exception of the old Calanaga and Bilbao mines, Batan is at present the only opening in the coal field on the eastern

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PLATE V.

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end of Batan Island. This field extends from Mount Viscaya on the west to Masaga on the east, to Calanaga on the north and Batan on the south.

Two seams, with an interval of 25 meters are known to exist: the upper 1.0 meter thick and the lower 1.5 meters thick. At present only the lower seam is being worked.

The coal is reached from the outcrop and a slope is driven in the seam 40° of the full dip of 15°. Near the slope are grouped the tipple, power plant, ventilating fans, office building, machine and blacksmith shops and a new 3,200-ton coal bunker, now nearing completion. A wharf and loading tower are located 833 meters from the mine.

The country around Batan is only a narrow coastal plain with a row of ridges following the coast line and rising to altitudes of from 30 to 400 meters. The surface is covered with a dense growth of underbrush and timber. The water supply is intermittent as the streams are small.

This field, resting in part on an igneous base is composed of sedimentaries: sandstones, shales and inter-stratified coal seams forming the coal measures, with a capping of coralline limestone on the hills and belongs to the Tertiary period.

The coal beds lie in the form of a monocline and have a strike of N. 75° W. The thickness of the coal as worked is 1.5 meters composing a shaley top coal 0.3 meter, a bottom coal 1.13 meters separated by a 7 centimeter sandy clay parting.

The coal is sub-bituminous and its quality is shown by the analyses given below. The coal crushes to a brown powder. It contains a small amount of sulphur and also lenticular bodies of resin varying in thickness from 1 to 15 centimeters and extending over small areas. The face and butt cleavage is well marked. This coal does not coke and air slacks.

The main slope has been driven 550 meters and the face of the workings is approximately 50 meters below sea level. Five entries have been driven from the slope to the right and left of which two to the right are now advancing.

One Ingersoll Rand pick machine and radial-ax coal cutter have been used to a limited extent and have given fair results. At present all coal is mined by hand and the whole face is mined with only a few inches of undercutting. The system of mining is the "room and pillar."

Mining has been rather difficult due to an exceedingly soft and heavy roof of considerable thickness. On exposure to the air the roof slacks and is continually falling. It is found necessary to timber all entries with tops of timber sets covered with lagging.

In some of the old workings it has been found that leaving the top coal remaining makes a good protection for the roof and this scheme is now being tried. The top coal is also of inferior quality and contains about 17 per cent ash. Marsh gas occurs in small amounts and has also a tendency to work the roof.

The timber used is *pagatpat* and is very satisfactory. Other equally good trees are *mangachapuy, dagon, molave, guijo,* and *narra.*

Since our last report two 200 horsepower boilers have been installed and one air compressor of a capacity of 1,050 cubic feet of air per minute and another one of the same unit is on the ground.

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A 3,200-ton coal bunker is nearly completed. This will be connected directly with the mine. A new rock fill connects the bunkers with the wharf and will make the surface haul nearly 100 meters shorter.

Natural causes and those associated with mining inclined seams have limited the output to some extent. An average daily output of nearly 70 tons was maintained during last year, although over 150 tons have been mined in a single day of 24 hours. It is expected that the production will be considerably increased. The storage capacity has been limited and the mine has been practically only worked to present full capacity when cargo ships have been present.

There is every reason to believe that the field will be thoroughly tested and proven this coming year and capital will be assured that coal mining can be successfully done in the Philippines.

Analysis of East Batan coal.[a]

Moisture	17.97
Volatile combustible matter	36.82
Fixed carbon	38.28
Ash	6.93
	100.00
Sulphur	.84

West Batan.—The military branch of the United States Government (not the Philippine Government) has reserved the western half of the island and has been exploring and developing there since 1904. All openings save the lowest one, near the beach, known as "New No. 5," have been abandoned. In this the coal is from 1 to 2 meters thick and is holding to its usual thickness 1 to 2 meters toward the east. While the coal seams were found to pinch and were probably more or less faulted to the west, it is fully believed that they will be found to continue more uniformly in the direction of the *barrio* of Tinicauan (eastward).

Since January 1, 1911, all work at the Government mine has been suspended.

The old Minas de Batan, properties on the eastern and northern portion of the island, have been abandoned. For several years a Spanish company employing Japanese miners, who used rather crude and wasteful methods, operated these properties, but the company failed.

Much trouble was experienced from water and from spontaneous combustion in old workings. Both of these troubles can be controlled in the future. The coal is quite rich in volatile matter, as can be seen by referring to the analysis given. In places, also, the coal contains a considerable amount of resin and sulphur and frequently takes fire on the dumps. When the writer visited the old Calanaga and Bilbao properties, on the north side of the island, there was evidence of this and the Bilbao tunnels are said to have been abandoned because of spontaneous combustion in the workings. These points are mentioned in detail, not to discourage investors or engineers who may wish to enter the field but to make the facts plain to them before they set out for a country situated at such distance.

[a] By Alvin J. Cox, Laboratory of General, Inorganic and Physical Chemistry, Bureau of Science.

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Batan Island is well situated directly in the track of steamers coming from San Francisco by way of Guam, which is the most direct route to Manila. A coaling station here would save the army transports the long northward trip to Japan where they now go to coal. On the other hand, it is off the track of many of the interisland trading vessels and large tramps touching at Cebu, Iloilo, and Manila.

CEBU.

Cebu is a long, narrow, mountainous island with no large rivers, few bays, and but little coastal plain, yet it supports a greater population in proportion to its size than any other island of the whole Philippine group. The city of Cebu is the second city at present of the Islands and a great distributing point.

Geologically, Cebu is much the same as Batan, with the addition of some crystalline schists, igneous flows, all of which may yet be found in Batan.

At least a dozen localities are known, scattered from one end of the island to the other where coal comes to the surface. Many of these are unfavorably located and, therefore, need no further mention here.

The chief localities to which most attention was paid by the Spaniards and to-day by Americans and Englishmen, are as follows: Camansi, 10 kilometers west of Danao; Monte Licos, 10 kilometers west of Compostela; Monte Uling, 8 to 10 kilometers west of Naga; and Alpaco, 4 to 5 kilometers west of Naga.

All of these deposits are situated on the eastern side of the Cordillera Central, the first two some 20 to 25 kilometers north of the city of Cebu (which lies about central on the east coast), and the last two 18 to 20 kilometers south of the same city.

Here we find sandstone, shales, and limestones in very much the same order as on Batan. However, the number and position of the local seams can be determined much better, for three reasons: First, more exploratory work has been done in these fields; second, the country is much more open, being quite denuded of trees, but there is an excessive growth of *cogon* grass which, of course, can be burned off; third, the country is more dissected and hence more and better sections can be obtained.

In the Camujumayan Valley the writer has seen four different seams exposed, the thickest measuring no less than 3.75 meters, the smallest about 0.75 meter, although only 0.5 meter of the latter is solid coal.

A great number of claims have been staked in these fields, but actual operations have been carried on only at Camansi and Mount Licos (Insular Coal Company). The tramway which existed in Spanish times has been put in order from the mines to the coast at Danao. Here the

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company intended either to trans-ship to the railroad now running to Cebu, or possibly, to build its own dock at Danao. Just now this work is suspended save for about 10 tons a week mined by the natives.

CAMUJUMAYAN VALLEY.

The Camujumayan Valley is located 15 kilometers northwest of Danao, in the Compostela-Danao coal field, and is 30 kilometers due north of Cebu. It may be reached by means of 30 kilometers of railroad which goes as far as Danao, then by 10 kilometers of tramway which ends at Camansi. The rest of the distance, about 5 kilometers, must be made on foot.

The country is very mountainous with a sharp relief and with an average elevation of 330 meters. Mount Mangilao is 684 meters above sea level and is the highest point in the district. The valleys are deep and V-shaped with sharp, bare ridges between them.

Almost all the hills are bare of trees; the only vegetation being *cogon* grass. The upper portion (limestone) of the highest points is covered with a good growth of timber.

The smaller streams have an intermittent flow, but Danao River flows at all times.

Elevations.—The point where the best outcrops are seen in this valley is 305 meters above sea level. The lowest point in the rim of this basin besides the last named point is 457 meters, a saddle on Mount Lantauan.

Camujumayan Valley is a syncline about 1 kilometer wide the axis of which is N. 45° E.

Rocks.—Both igneous and stratified rocks are found, but as the igneous rock occurs only at the lower end of the basin it can be neglected.

The sedimentary rocks are much the same as in all the other coal fields of the Philippines, shale, sand-stone, and limestone with interstratified coal seams. There is also a very much oxidized conglomerate above (stratigraphically) the coal measures which must not be confused with the basal conglomerate. In 1907 Mr. Benjamin Smith Lyman made a survey of a part of this valley for a private company. No accurate data are at hand regarding thickness of the lower formations or the depth of the basin. The upper limestone is about 213 meters thick. This limestone is very pure.

No definite data regarding faults exist, but it is thought that faulting on the east side of this basin will probably be found.

There are four coal seams: No. 1, 1.5 meters thick; No. 2, 3.75 meters thick; No. 3, 3 meters thick; No. 4, 0.5 meter thick. These are numerated in order, No. 1 being lowest stratigraphically.

The coal has a brilliant, black color on fresh fracture; it is usually quite hard in portions of the seam, and gives a brownish powder. It has a rather dull, vitreous luster with fine coatings of iron pyrites on some

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surfaces; shows a blocky cleavage but the cleats are not regular, and it burns without any evidence of coking. The several seams contain small clay partings and "bone," usually not over 2.5 centimeters in thickness. However, the coal will have to be carefully cleaned.

The analyses below give the average above and below a small parting in No. 2 seam and also of seam No. 3.

Analyses of coal from Camujumayan Valley.[a]

Constituent.	No. 2 seam.		No. 3 seam.
	Upper half.	Lower half.	
Water	23.18	17.24	13.88
Volatile combustible	46.40	44.13	40.87
Fixed carbon	25.84	33.87	41.74
Ash	4.58	4.76	3.41
Calories	4,428	8,190	5,761
Sulphur			0.65

[a] Analysis by Forrest B. Beyer, Bureau of Science.

CAMANSI DISTRICT.

This field is situated on the Danao River 10 kilometers due west of Danao, which is the nearest town; it is a part of the Compostela-Danao coal field.

The region near Camansi is very hilly, although the village and present workings are situated almost in the river bottom. The sharp relief of this region is due largely to erosion. The surface is very bare and hence is greatly indented with gulches. The only vegetation is *cogon* grass except on the limestone ridges where timber of the third and fourth groups is found.

The timber supply is sufficient for a period of 5 or 6 years. Later it may be brought in cheaply from Negros by way of Danao. This timber can be secured cheaply, as 1 peso per set was paid in Spanish times. The chief classes are *putian* and *naucaon*.

The Danao River furnishes an abundant supply of water for mining operations.

The terminus of the tram road and the site of the former working is 80 meters above sea level. The hills in the vicinity rise to an altitude of 300 meters.

GEOLOGY.

The rocks here are essentially the same as those in the other two fields in this region, they are shale, sandstone and limestone. The lower portion of the limestone is marly. A short distance to the west of Camansi is the edge of the igneous formation.

This field is best described as a monocline, though there are some minor folds best seen in the cut on the tram road just east of the present San Luis tunnel. One or two faults were encountered during early Spanish operations, but I have no further definite information concerning this

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point. However, I am of the opinion that the great Licos Escarpment marks the existence of a fault.

The coal seams are four in number and given from west to east are: Espina, (small); Santa Barbara, (1 to 1.5 meters); No. 5, (1.5 to 2 meters); San Luis, (0.5 to 1.25 meters).

These seams occur in the Tertiary formation, and are of about the same thickness as the Mount Licos seams with which they are correlated.

The coal is black, very firm, hard, and strong and gives a black powder; has a brilliant luster and is free from impurities. This coal has no regular cleavage and does not coke. Below is an analysis of the San Luis seam, the only one open at the time of the last visit.

Analysis of coal from the San Luis seam.[1]

Water	9.01
Volatile combustible	43.46
Fixed carbon	43.18
Ash	4.35
Sulphur	2.40
Calories	6,249

THE MOUNT LICOS (COMPOSTELA) FIELD.

A fairly complete report has already been made on this field.[2] There are four workable seams as follows:

1. The "Carmen." Thickness 1.60 meters, strike NE. to SW., dip 30° SE., 40 meters interval. 2. "Esperanza." 50 centimeters, strike and dip the same as above, 9 meters interval. 3. "Enrique Abella," 1.20 meters to 1.50 meters, strike N. 23° E., dip 40° SE.; 40 meters interval. 4. "Pilarica." 1.40 meters, strike N. 23° E., dip 30° SE.

Formerly, a considerable amount of work was done on these seams. In Spanish times practically the only active coal mine was located here. All operations were suspended at the outbreak of the insurrection in 1896.

Since 1907 there has been no work.

Analysis of the average coal from the Mount Licos field.[3]

Water	8.60
Volatile combustible	36.95
Fixed carbon	51.75
Ash	2.70
Total	100.00
Sulphur	.71
Calorific value in calories	6,380

[1] Analysis by Forrest B. Beyer, Bureau of Science. Samples taken according to United States Geological Survey regulations by Warren D. Smith.

[2] Smith, W. D., The Geology of the Compostela-Danao Coal Field *Philip. Jour. Sci., Sec. A.* 1907), **2**, 377.

[3] Analysis by Alvin J. Cox, Bureau of Science, by the "smoking off" method, which gives slightly higher figures for fixed carbon than by the official method.

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OTHER LOCALITIES.

There are five other localities which at times have commanded some attention. They are Polillo; Bulalacao, Mindoro; Dinagat; Cataingan, Masbate; and Sibuguey Bay, Mindanao. The first is an island due east of Manila, off the east coast of Luzon; the second is on the Island of Mindoro; the third, a small island just north of Surigao Province, Mindanao; the fourth is at the southeastern end of the Island of Masbate; and the last about 150 kilometers northeast of Zamboanga.

GUINIBACAN RIVER, POLILLO.

In Polillo exploration has shown that there is apparently a considerable supply of coal. It is similar in many respects to the west Batan coal. The geographical position of the island may be a factor against it in its competition with other fields. It is entirely off the present track of steamers but a port on the east coast would change these conditions.

Geology.—The rocks in this coal field are sedimentaries: conglomerates, sandstones and shales, sandstones and limestone flanking an igneous complex. The sediments lie in the order named above from the bottom upward. The limestone is probably unconformable, though not seen in contact, judging from other fields in the Philippines. The ideal section below graphically represents the relations.

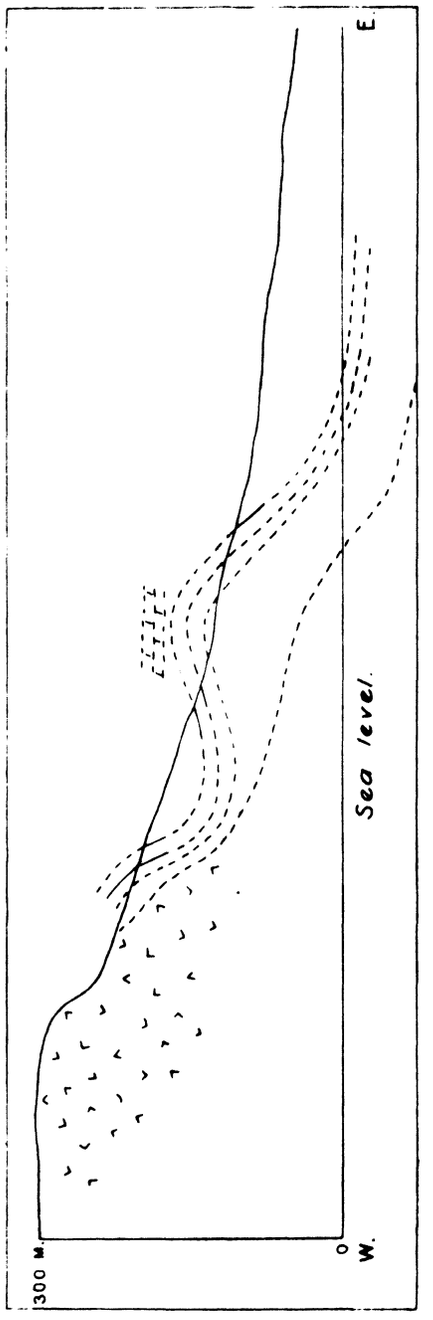

FIG. 2.

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Beginning with the bottom, we have a fine-grained, slightly porphyritic igneous rock which has a greenish cast, in places almost white. We know that this rock is *older* than the sedimentaries because pebbles derived from it occur in the basal conglomerate.

The shales, which are grayish to buff, grade imperceptably into the sandstones and grits. They are similar to the shales in other parts of the Archipelago where coal has been found.

The sandstone is gray to greenish on fresh surfaces and weathers to dirty yellow. It is quite impure and carries, comparatively, very little quartz, being derived largely from the disintegration of the igneous rock. The sandstone grades through grit into the conglomerate. The limestone is found only in residual patches. It is very white and largely coralline. It was originally deposited as a blanket above all the other formations. There is one well marked anticline and syncline with two monoclines. While the average axis is N. 20 W. there are local variations from this.

A few small faults are inferred, but as yet no definite information is at hand on this point.

The lithology and the fossils in the shale, although not many of these have as yet been found, point to the fact that this coal belongs to the same period as the others of the Philippine Islands i. e., Oligocene and Miocene of the Tertiary period.

In Guinibauan Creek we get the best exposures, according to Captain Wray and Mr. Ikis, of any part of the Island of Polillo. From our own field observations, we are certain of only three coal seams of any size worth considering and probably there are only two which could be worked profitably. It may finally be narrowed down to one, the "Wray seam."

At the Wray mine the coal contains from 1 to 2.5 centimeters of sooty clay parting. The coal is hard and firm, especially in the lower portion of the seam; it is shiny-black in the upper part and brownish-black in the lower, with angular shiny particles cemented in a coal matrix. It has a bright to dull luster and gives a black powder. No well defined cleats appear, but it presents a characteristic slickensided or surface shear. It does not coke and does not air slack.

Analysis of coal from the "Lower Mine," Polillo.[a]

Water	8.28
Volatile combustible	41.53
Fixed carbon	46.31
Ash	3.88
Sulphur	0.32
Calories	6,775

Conclusions in regard to the geological conditions affecting the coal.—(1) The coal field is bounded definitely on the west by the volcanic rock.

[a] Analysis by Forrest B. Beyer, Bureau of Science.

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(Fig. 2.) (2) The coal beds do not appear to be entirely continuous in a north and south direction—witness the almost entire absence of outcrops in the north branch of Guinibauan Creek. This may be due, however, to talus covering the outcrops. (3) The coal seams are flattening toward the coast, and will be found in all probability of different grade from the more highly inclined seams to the west. (4) The hard, peculiar condition of the bottom coal of the "Wray" seam might be used as a means of correlation. Its peculiarity is not, in my opinion, due to coking. My reasons are these: (*a*) the underclay is not baked. (*b*) The volcanic rock was cold before the sediments were laid down. (*c*) There is no volcanic rock in contact with this seam at the point examined. (5) The folding of this region was due to lateral thrust against an abutment of resistant rock, the igneous complex in the center of the island. There are no indications of intrusions. (6) Given continuous seams, which will have to be proved by more excavations, there is nothing prohibitive in the geology. Mining operations will, however, not be simple as the beds are highly inclined in places.

Coal has been found at several other points on Polillo, but we have made no examination of them. There is apparently a fairly extensive field on this island.

SIBUGUEY COAL MINE.

Geology.—This field is situated about 12 hours steaming from Zamboanga and northeast of that place on the Sibuguey River which flows into Sibuguey Bay. The deposits are found about 20 kilometers from deep water. The coal seams occur in the usual shales, below the same gray sandstone found in most Philippine coal fields. There are patches of volcanic agglomerate above the coal measures in Alat Creek. It is my opinion that this agglomerate is of much later origin than the coal and consequently could not seriously have affected it, however, much more work is necessary before the exact relations can be determined.

The axis of the field is apparently parallel to the main cleats, N. 18° W. and the dip of the coal is S. 20° W. At present no data have been obtained in regard to faults.

These coal seams belong to the Tertiary period and are two in number:

No. 1.—1.5 meters.

No. 2.—2.4 meters according to Mr. Williamson of Zamboanga who was one of the original locators.

There is some tendency for the 2.4 meters seam to pinch, but not enough work has been done to make any definite statement about this point.

The coal is black, with bright luster and gives a black powder. There is a slaty parting in the 2.4 meters seam varying from 1.2 meters to 1.8 meters, but the 1.5-meter seam is very clean. This latter has a good

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cleavage and shows the strike of the main cleat N. 18° W. with a dip of N. 72° E. The coal is firm and is secured in lumps which do not air slack. It forms a hard, coherent coke according to Sir W. Bovarton Redwood. The analyses are given below.[1]

Water (combined)	19.45
Volatile combustible	26.60
Fixed carbon	51.35
Ash	2.60
Sulphur	0.44
	100.44

This coal yielded 52 per cent hard, coherent coke. The lignite treated as an oil producer (shale industry) yielded a very large quantity of luminous gas of great illuminating power and gave:

Oil (solid at 58° F.)	gallons	31.5
Ammonia	do	32.0
Coke	hundredweight	12.5

This coal was tested at Cavite, P. I., April 18, 1902, by the Navy steam engineering department and they found its efficiency to be about 63 per cent of Pocahontas coal.

The following[2] is an analysis of a recent sample collected by me:

Moisture	6.81
Volatile combustible matter	45.45
Fixed carbon	45.92
Ash	1.82
Sulphur	.43
Calories	6,681
B. T. U.	12,026

Sibuguey Bay, which I visited in the winter of 1907–8 (see Mineral Resources, 1908) and again in February, 1911, has a favorable location, as lighters can go up the Siay River (a distance of about 20 kilometers from the sea) to within 100 meters of where the shafts or drifts would in all probability be located. For outcrop coal it has a more prepossessing appearance than that from most of the other districts with the exception of that from Dumanquilas Bay, Mindanao. The beds are tilted, but not so much as in other localities and timber is very plentiful and close at hand. The country is still a wilderness, and it is not altogether safe for white men to live there except in some numbers. The natives of the immediate vicinity (Subanuns) are fairly quiet and friendly.

These coal measures must continue around the head of the bay and

[1] Mr. J. C. Butterfield, through Sir Bovarton Redwood Laboratory, Westminster Chambers, 13 Victoria Street, London S. W., March 11, 1901.

[2] Analysis by Forrest B. Beyer, Bureau of Science.

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into the Zamboanga Peninsula where the prevailing rock is a crystalline schist. The writer fully believes drilling at indicated points on this peninsula will show a higher grade of coal, not improbably an anthracite, as a result of the great compression to which the strata in this region have been subjected.

DUMANQUILAS BAY.

Since my first visit to this region, when I predicted that somewhere in the Zamboanga Peninsula a much better grade of coal would be discovered, Mr. Cleveland has located a semianthracite coal having a fixed carbon content of 82 per cent near the Tres Montes peaks on Dumanquilas Bay. As yet only a 0.5-meter seam has been uncovered, but the field is a promising one. The following is a synopsis of conditions as I found them in February, 1911.

Mr. Cleveland's claim is located at the foot of the eastern peak of Mounts Tres Reyes near Margosatubig in Dumanquilas Bay about 5 kilometers from tide water, and is within the Moro Province, District of Zamboanga. It is about 200 kilometers northeast of Zamboanga.

The country is rolling in outline near the coast, with small mountains to the west with a plateau country at elevations of from 100 to 150 meters in front of the mountains.

The surface is covered with a light forest, usually of second growth with patches of big timber comprising the following classes: *narra*, *yacal*, and *pagatpat*.

Geology.—The rocks are sedimentaries, comprising sandstones and shales, but no limestone was seen. Probably remnants will be found on the neighboring hill tops; the same sequence is shown here as found in all Philippine coal fields. Volcanic andesite boulders from an old flow which is largely eroded but lies stratigraphically above the coal, are numerous in the streams.

As less than four hours was spent in this vicinity we have only a limited amount of data regarding this prospect. Practically no exploration and no development work has been done.

The coal occurs in the Tertiary formation and only one seam is known, which is very irregular in thickness, between 0.33 and 0.5 meter.

The color of the coal is steely-gray, with a black powder; the luster is very bright; it shows a fair cleat at No. 1 outcrop. At No. 5 outcrop a "columnar basalt" crystalization occurs in the coal, apparently perpendicular to the bedding planes, in long, narrow, five- and six-sided prisms which give a honey-comb effect on the surface. As the clay below is apparently unaltered and as there is no sign of igneous rock in immediate contact with the coal, the phenomenon can not be easily ex-

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plained, unless the coal formerly was in contact with a volcanic flow which has since been eroded.

The coal is said to coke and is used for steam and forge purposes.

Analysis of coal from Dumanquilas Bay.[a]

	Per cent.
Moisture	1.85
Volatile combustible matter	10.43
Fixed carbon	82.34
Ash	5.38
Total	100.00
Sulpur (separately determined)	0.82
Noncoking coal.	
Color of ash	Reddish brown
Calorific value	7,695

SOUTHEASTERN MASBATE.

In Spanish times more or less exploration was carried on at Nabangig, about an hour's steaming from Cataingan Bay.

In 1909 a Manila company carried on more or less exploration work here, having a geological survey made first by Mr. H. G. Ferguson, geologist in the division of mines, Bureau of Science. As far as this work went Mr. Ferguson found no prohibitive conditions, but later work by Mr. Kimball revealed some pinching of the seams near the outcrop. However, this is not an unusual condition and does not condemn the property.

Geology.—The rocks of this field consist of stratified sedimentaries, shale, sandstone with coal seams, and limestones as follows:

Gray sandy shale; gray impure sandstone weathering to dirty yellow; buff-colored limestone. These are flexed into positions varying from 45° to almost 90°.

Uncomformable to and above these formations is a white limestone capping, now only seen in residual patches. Occasional blocks of "grit" were seen in the creek. I think these belong with the coal measure series, as I have seen the same thing on the west end of Batan overlying and underlying the coal. The "nodular limestone" referred to by Mr. Ferguson is, in my opinion, not a distinct formation and can not be used in correlation.

Not enough sections or excavations were seen by me to enable me to arrive at any idea of the thickness of these formations.

According to Mr. Ferguson the formations in the vicinity of Nabangig Creek are flexed into close folds, antilcines and synclines striking NW. and SE.

[a] Analysis by Forrest B. Beyer, Bureau of Science.

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I am inclined to think that the folding is not as close as represented by Mr. Ferguson, as I do not believe the "nodular limestone" can be relied on. However, I must state, that I was on the ground only two days and could not in that time study the formations as carefully as Mr. Ferguson could. One or two small faults are inferred by Mr. Ferguson, but I had no opportunity to note any, however, I would expect them in this district.

The coal occurs in the upper Oligocene and Miocene of the Tertiary period.

Coal beds.—Mr. Ferguson assumes that there are three distinct seams. He lists 65 outcrops, of which 10 are reported by the Spanish engineer Abella and were found by Mr. Ferguson. Of the remainder, only two showed a width of 1.50 meters or more, namely No. 57, 1.55 meters and No. 45, 2.05 meters. The first he says is on the upper seam and the second on the middle one. Mr. Ferguson thought that he could trace three distinct seams, but not enough development work was done to make this definite nor to determine with any exactness the quantity of coal which could be assured.

Quality of coal.—The color of the coal is black, giving a black powder. It shows a satiny luster and is free from any clay or sandy parting away from the outcrop; it is firm and hard and shows no air slacking.

The cleats are said to be well marked but I did not see enough in the outcrop to enable me to make a statement.

Average analysis of Nabangig coal.[a]

	Per cent.
Moisture	4.87
Volatile combustible	40.50
Fixed carbon	44.18
Ash	4.45

MINDORO.

At Bulalacao conditions appear to be not essentially different from those on Batan, the geographic location is favorable, but there is no other interest there to make it worth while for the steamers to run in, an advantage which Cebu enjoys. Moreover, the coal is of an inferior grade.

DINAGAT.

Dinagat Island is still more isolated. I visited this island in February, 1911, and inspected the outcrops near Loreto, but found that the visible seams were too small to be worked, they are less than 0.5 meter in thickness and of inferior quality.

[a] Analysis by W. B. Gonder, Bureau of Science.

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LABOR AND COSTS.

The average wages for the various classes of natives (Bicols) employed at the Batan mines are as follows:

	Pesos per day.
Mine foremen	2.00
Carpenters	1.50
Miners	1.20
Laborers	1.00
Laborers (outside)	0.80
	Pesos per month.
Clerks, storekeepers	30.00
Firemen	30.00
Engineers	40.00 to 60.00

THE CHEMICAL AND PHYSICAL PROPERTIES OF PHILIPPINE COALS.

As Dr. Alvin J. Cox, of the Bureau of Science, has discussed this phase of the subject I shall merely refer the reader to his articles.[1] From the analyses given in this report it can be seen that there is considerable variation and that we have true bituminous coal as well as lignites.

UTILIZATION OF PHILIPPINE COAL.

Philippine coal can be used in the following ways: (1) Burned alone; (2) mixed with better coal; (3) in gas producers; (4) in the shape of briquets.

1. Coal from Polillo, Cebu, and Sibuguey and Dumanquilas Bays, Mindanao, can stand on their own merits and be burned alone for steaming and other purposes. They are all bituminous coals with the exception of the coal from the last-named locality and that would more properly be called semi-anthracite.

2. Coals like those from east Batan, Mindoro, and Dinagat while capable of being burned alone in properly constructed grates are materially improved by being mixed with Australian coal. The Manila Electric Light and R. R. Company has done this with very satisfactory results in the case of Batan coal. These coals can be made to produce much better results by using finer grates, longer fire-boxes and some device for returning the unburned gases through the furnaces before passing up the chimneys.

3. Batan coal has been used in a German gas-producer which is expected to be on the market very soon. One of these has been bought by the Bureau of Science. The gas producer will undoubtedly play an important factor in the future of Philippine coal.

4. Experiments on the briquetting of Philippine coal have recently been undertaken.

[1] *Min. Resources P. I. Bur. Sci. Div. Min.* (1908), 34.

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The Bureau of Mines in Washington is now experimenting with Philippine coal in perfected machines. As one briquetting machine costs in the neighborhood of 60,000 pesos, the Bureau of Science has been unable, owing to the lack of funds, to take up this important line of investigation on a large scale, but has done what it could with the apparatus at hand.

Coal briquets have been made both with and without binders in the laboratory of the division of mines. The latter method is not usually productive of satisfactory results. The possible binders for coal briquets are the following: (1) Pitch; (2) starch; (3) molasses; (4) sugar mill waste (bagasse); (5) tar from gas plants; (6) rice polishings (tiquitiqui).

The first and fifth in this list are out of the question now, for we have no local supply. The second can not be considered because starch will bring more in the market than will the briquetted coal. No molasses is made in the Philippines. No. 4 might be utilized but has not been tried so far. This is used by itself as fuel in the sugar districts. The sixth has been used by us in our experiments in the Bureau of Science with the results that a very fair briquet has been made.

Mr. Pratt's results will be found in the appendix at the end of this bulletin on page 79.

CONCLUSION.

In conclusion we might sum up the unfavorable and the favorable features connected with the subject of coal in the Philippines. The less favorable features are:

1. Some pinching of the seams in places.
2. Weak roof and floor in some fields.
3. Inferior grade of the coal in some of the more accessible fields.
4. The labor at present is almost unskilled.
5. Difficulties attending exploratory work, such as the jungle, lack of roads, etc.

The more favorable features are:

1. An exceptionally good local market.
2. Cheapness of the labor (per diem). The labor is easily managed.
3. Abundance of timber.
4. Distance from possible competitors.

Whether these last named can offset the first is only to be ascertained by actual trial. The writer believes they can and that coal mining can be carried on at a profit in the Philippines.

Any estimates of the amount of workable coal available in the different fields would be only guesses in the absence of more development work. There seem to be, however, many million tons which can be extracted from the total area of land in the Archipelago underlain by coal.

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It must be said that the present mining laws are not as favorable to capital as they might be. A remedial bill is now before the Congress of the United States, and it is sincerely to be hoped that it will become a law. Certainly, the Government should recognize the importance of making some concessions in order that capital will be encouraged to come in and develop this most important resource.

LIST OF WOODS AND THEIR BOTANICAL NAMES.

1. Narra =*Pterocarpus indicus* Willd.
2. Dagon =? *Tarrietia sylvatica* Merr.
3. Molave =*Vitex parviflora* Juss.
4. Guijo =*Shorea guiso* Blume.
5. Mangachapuy =*Vatica mangachapoi* Blume.
6. Putian =*Sideroxylon* (?)
7. Naucaon, Bacauan =*Rhizophora conjugata* L.
8. Pagatpat =*Sonneratia pagatpat* Blanco.
9. Yacal =*Hopea plagata* Vid.

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IRON IN THE PHILIPPINES.

By WARREN D. SMITH and PAUL R. FANNING.

Pig iron imported into the Philippine Islands in 1910.

	Kilos.	Value in pesos.
United Kingdom	943,353	15,461
China	50,800	770
Hongkong	54,961	1,133
Total	1,049,114	17,364

No pig iron is produced in the Philippine Islands, except a very limited quantity by the natives of Bulacan Province. If our manufactures increase, we must produce our own iron, and to produce it we must have coking coal. We have found scarcely any up to the present time, so the development of one should go hand in hand with the other.

The places where promising iron ore bodies have been found are as follows: Near Mambulao in Ambos Camarines; in the hills back of Bosoboso, in Rizal Province; at Lanatin and Angat in Bulacan. There seems to be a well defined belt running from Ambos Camarines north along the Eastern Cordillera. How much farther north than Angat it extends we do not know. The deposits of Bulacan have been described in several places, those at Angat by H. D. McCaskey,[1] former Chief of the Mining Bureau; those at Lanatin by Dr. G. I. Adams.[2] Those at Bosoboso have never been exploited. The deposits near Mambulao have received a preliminary examination from Paul R. Fanning, assistant, division of mines, Bureau of Science.

The deposit of hematite takes its name from its occurrence on Calumbayanga Island where the exposures are particularly conspicuous. This island is situated some 6 kilometers west of the town of Mambulao, Province of Ambos Camarines, Luzon, Philippine Islands. It lies at a point about 200 kilometers, nearly due east of Manila and may be reached

[1] *Bull. P. I. Mining Bur.* (1903), No. 3.
[2] *Philip. Journ. Sci. Sec. A* (1910), 5, 57.

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overland in two or three days, or in three days by coastwise boat. The immediate area is of moderate relief and the hills to a great extent represent base leveling.

As can be seen from the map, the island is not very large and has an elliptical base perimeter of about 4 kilometers. The axis of the hill is orientated northward by reason of the northward strike of the hard hematite outcrop. An elevation of about 85 meters above sea level is attained toward the northern end of the island. Between the island and the mainland there is a shallow sheet of water about 1 kilometer wide. It is probable that the hematite is there covered by a coral reef which hides its extension to the adjacent mainland. On the mainland the outcrop quickly attains a persistent elevation equal to that on the island.

Several small streams are found on the island, but the amount of water is small owing to the limited catchment area. During the rainy season, for perhaps six months in the year, there should be no difficulty in obtaining an abundant supply of water for all mining purposes. Water in abundance occurs on the mainland, and at an elevation sufficient to pipe to the island. This can be secured during the entire year. The whole region is covered by the usual dense tropical forest and other vegetation. Many of the native woods are extremely hard and durable and serve excellently for mine or general construction timbers.

Soil of a possible thickness of 3 meters occurs generally over the area, except on the hematite where owing to the resistent nature the soil is somewhat thinner and is made up mainly of softer hematite or limonite, mixed with innumerable boulders of the harder hematite. Indeed a striking feature of the formation is the size and quantity of these boulders.

Calumbayanga Island seems to be entirely comprised of sedimentaries in which the hematite occurs. The strata to the eastward give evidence of a shallow water deposition, and are now of an impervious nature which to some extent may have had an influence on the formation of the hematite. The origin of the latter is as yet a matter of conjecture, but the evidence suggests that the iron was originally leached from the basic schist, carried to shallow water, precipitated there, and later concentrated by descending waters adjacent to the impervious shale and conglomerate.

The ore can be traced for a distance of over 3 kilometers and on the surface where revealed by true outcrops the width varies up to 15 meters. Owing to the scarcity of true outcrops it can not now be said that this is the average width, and because of the mode of formation, the probability is that the outline of the deposit is quite irregular. The trend of the ore body is N. 10° W., that is, parallel to the sedimentaries. The dip, if conformable with this, will be 70° to the southwest.

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The quality of the hematite is shown by the following analyses made by Mr. Dar Juan, Bureau of Science:

Constituent.	Sample No.—		
	1.	2.	3.
	Per cent.	*Per cent.*	*Per cent.*
Iron	57.11	63.69	46.06
Phosphorus	0.001	0.005	0.008
Sulphur	0.138	0.070	0.067

Sample No. 1 is a mixture of pieces broken from many boulders and a few outcrops along a distance of 1,000 meters on the island.

Sample No. 2 is a mixture of many pieces broken from boulders along a distance of 500 meters on the adjacent mainland.

Sample No. 3 is a single lump specimen.

Other analyses have shown an iron constituent averaging 60 per cent.

The hematite is very compact and hard, and in appearance is very similar to the hard Lake Superior ore such as that from the Vermilion Range, Minnesota. Some specular hematite in flat crystals is occasionally seen and a small amount of magnetite is not infrequent.

The quantity of hematite can not be estimated at the present time because experience of other fields where enormous quantities were indicated on the surface shows that they may not be realized at depth. Whether or not this will be true for this formation is a matter for future development to determine.

The factors involved in an estimation of the cost of mining this ore are as yet too uncertain to approximate any just figure.

The ore above sea-level will easily be drained by tunnel and no pumping will be necessary. The proximity to the sea should not be a very serious factor in pumping at depth, owing to the impervious nature of the sedimentaries. For the present it will probably be advisable to ship the ore rather than to smelt near the mine. However, soft coal (non-coking) and limestone can be had at a low cost. The island is so situated as to afford a safe harbor sheltered from all typhoons, and a dock to deep water can easily be constructed.

Conclusions.—The surface indications are excellent, yet the amount and quality of the ore are unknown. It is unquestionable, however, that the property is worthy of extensive development.

BULACAN DEPOSITS.

From our examination of the Bulacan deposits we can say that they are very irregular and occur with igneous rocks of the Eastern Cordillera as local enrichments from the alteration of chalcopyrite and other iron bearing minerals of that formation. The rich pockets which we exam-

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ined near Angat, and from which the natives mine their ore, are located along fractures in the formation. To make a thorough examination of these deposits would necessitate a considerable amount of capital and involve the use of the diamond drill. While the natives of Angat get very fair returns from their crude operations, the exploitation of these deposits can not successfully be carried on except by a large company.

We mentioned above the use of coking coal. The amount of coke necessary for the reduction of the iron oxide has been materially reduced by the invention of a specially constructed electric furnace which was first operated in Sweden. In such a furnace, where formerly it required 1,000 kilograms of coke to reduce a given amount of iron ore, only 275 kilograms now are needed. This brings up the question of the development of electricity, and unless it could be transmitted from Manila, water power facilities would have to be sought in the Bulacan mountains where they undoubtedly exist.

The production of iron ore in the year 1910 amounted to 20,023.00 pesos. The largest producer is Doña Maria Fernando, a Tagalog woman living in Angat. During the autumn and winter months a party from the division of mines will make a geological survey of the Bulacan field and by means of the dip needle attempt to trace the iron formation.

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PRODUCTION OF NONMETALLIC MATERIALS IN 1910.

By WALLACE E. PRATT.

The production of nonmetallic minerals in 1910 is greater than in 1909, largely because of the gradually increasing use of strong materials in construction in the Philippines.

Stone.—Crushed stone, as a building material, is used principally in reinforced concrete work. Very little cut or dressed stone has been employed since the Spanish régime. While river gravel is more widely used in concrete aggregates owing to its lower cost, crushed stone is employed in the best class of construction. The greatest consumption of crushed stone at present is as road metal. The city of Manila uses nearly 60,000 cubic meters a year for this purpose.

In order to secure a better stone, the old city quarry on Talim Island has been discontinued and a contract for next year's supply entered into with a local company which will operate a quarry in Cavite Province near the mouth of Manila Bay. The Bureau of Public Works used about 40,000 cubic meters of crushed stone in building and maintaining provincial roads. The cost of crushed stone exclusive of transportation varies from 1.50 to 2.50 pesos per cubic meter.

Rough stone.—The Sisiman quarry has supplied about 60,000 cubic meters of rough stone (andesite) for use in the building of the Manila-Cavite Boulevard, and the Fort McKinley Quarry has furnished 18,000 cubic meters of Guadalupe stone (volcanic tuff) which is used as a basal course in Manila pavements.

Gravel.—Gravel is used extensively as ballast by the railroad companies and in concrete construction. The average price paid for gravel exclusive of transportation is about 0.80 peso per cubic meter. The Bureau of Public Works used 223,800 cubic meters of gravel in 1910 as compared with 325,000 in 1909.

Sand.—Sand is used in general construction and by the railroads in surfacing road beds. The Manila supply, as in past years, has been obtained mainly by dredging along the Pasig River. The cost of the sand, exclusive of transportation, varies from 0.20 to 0.75 peso per cubic meter. It is delivered in Manila at prices ranging from 0.90 to 1.30 pesos per cubic meter.

Lime.—Lime for Manila consumption comes principally from Binangonan, Rizal Province, where it is burned from a pure limestone. The product is usually partly slaked. It is probable that as the gold mining industry grows, a demand for lime will arise for use in neutralizing solutions from acid ores in cyanide mills. Lime is burned for local use at many places throughout the provinces. All the lime employed in the sugar industry of Panay and Negros comes from Guimaras Island limestone, which, as Mr. H. S. Walker of the Bureau of Science has shown, contains too much magnesium carbonate to be well adapted to this purpose.

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Clay products.—The pottery industry has received a decided impetus from the industrial work of the Bureau of Education. Several students from the pottery school at Santa Cruz, Laguna, are building a kiln at Majayjay and will engage in the business of manufacturing common ware for sale.

The pottery school at Santa Cruz, under the principalship of Mr. C. H. Crowe, has kindly supplied the division of mines with some firing tests of the clays submitted to it, from which the following table is compiled.

Firing tests of clays.

Clays.	Shrinkage.		Color.		Remarks.
	Air.	Fire.	Air.	Fire.	
	Per cent.	*Per cent.*			
60 per cent Los Baños crude clay, 30 per cent Santa Cruz clay, 10 per cent Santa Cruz fine sand.	6	3	Gray	Light brick	Semirefractory fire brick.
66⅔ per cent Matiquio crude clay, 33⅓ per cent Santa Cruz fine sand.	8	1	do	Gray	Semirefractory fire brick.
Ilocos Norte clay No. 1	11	1	White	White	With slight recomposing will make porcelain.
Zambales No. 1	5	3	Light gray	do	Suitable for porcelain.
Zambales No. 3	4	1	White	do	

The industrial division of the Bureau of Education has collected statistics which show that pottery is manufactured in 261 towns in the Philippines, exclusive of the Moro Province. Of these towns, 127 export pottery to the neighboring towns and provinces. The manufacture of brick is reported from 8 towns.

In the manufacture of brick the Filipino employs a beehive-shaped kiln usually made of Guadalupe stone (volcanic tuff) luted with clay. These kilns vary in size from a capacity of 30,000 to 50,000 bricks. They are fired from a single port which opens into a firebox below the general level of the kiln floor. The flues pass from beneath the floor of the kiln to a detached stack so that the firing is "down" draft in principle. Wood (faggots) is used for fuel. One firing takes about two weeks and requires from 150 pesos to 200 pesos worth of fire wood.

The clay used is usually alluvial and is prepared for moulding by tramping with carabaos. Bricks are moulded in hand presses and are dried under cover for about three weeks. Brick moulders (two men) turn out about 3,000 bricks per day for which they receive 0.75 pesos per thousand.

The product is a soft, red brick suitable only for light use. The industry centers around Manila and Iloilo. The production at Iloilo is about 500,000 bricks per year, which are largely used in sugar mill construction.

A well constructed continuous process brick kiln of modern design is standing idle on the Pasig River near Manila. It is a down-draft kiln using coal for fuel and has 12 chambers each of 8000-brick capacity, communicating with a central stack. Evidently this kiln was built by its owners before they learned that the clay available to it would not stand the high temperature which the kiln afforded.

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The status of brick manufacture remains unchanged. There is little demand for the inferior brick burned in native kilns. If a suitable vitrified brick were produced it should find a considerable market as a paving material in Manila, Cebu, and Iloilo. The brick on the market in Manila sells for 15.00 pesos to 25.00 pesos per thousand.

Salt.—Unrefined salt is produced by the natives all over the Archipelago from the evaporation of sea water, a process which is described in Mineral Resources for 1909. In the Asin Valley, in northern Luzon, the Ifugao people utilize the water from a salt spring for making salt. The importation of salt into the Philippine Islands amounted to 113,510 pesos worth during the fiscal year of 1910.

Cement.—The importations of cement during the last calendar year amounted to 333,592 barrels (380 pounds net). Cement is worth about 5 pesos per barrel on the Manila market. Capital has finally become active in the matter of manufacturing cement in the Philippines, and preliminary investigations as to the most advantageous location for a plant are under way. The present consumption would afford a market for the entire output of a small mill, and with the cost reduction which should result from local manufacture, the consumption would be greatly increased.

STATISTICS OF PRODUCTION.

Nonmetallic materials produced in 1908, 1909, and 1910.

[In pesos Philippine currency.]

Product.	1908	1909	1910
Stone	149,980	311,177	372,575
Gravel	171,360	289,550	232,459
Sand	35,000	85,500	60,997
Lime[a]	20,000	69,656	70,000
Salt[a]		375,368	380,000

[a] Estimated for 1910.

Importations of cement.

[In pesos Philippine currency.]

1908	1909	1910
1,384,202	1,554,674	1,667,960

Precious stones.—Recently some fragments of three gem stones have been brought in by a prospector, Mr. Cunningham, who states that they were found in Mindanao. They belong to three species: beryl (emerald variety), spinel ruby, and garnet. It is the intention of Mr. Cunningham to continue his explorations.

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TAYABAS OIL FIELDS.

By F. T. EDDINGFIELD.

No more is known now about the actual probability of finding oil in Tayabas than was known a year and a half ago. At that time there was a great rush into this field, hundreds of claims were located, and many companies formed; since which time each company has been waiting on the other for further work and development. One company indeed erected a boring rig, but so far as is known only very little work has been done. Although it is not known that oil really exists in paying quantities in Tayabas, neither is it known that it does not; consequently the locators for the most part still retain their claims. An article published in the appendix to the report of the Philippine Commission for the year 1908, gives the following data:

"From these preliminary prospects, which on analysis proved that the indications pointed to a high grade of oil, the interested parties have pushed forward their work on a more extensive scale. The Tayabas Mutual Oil Association was organized, with Mr. E. W. McDaniel as managing director, and prospecting work was carried on in more efficient manner.

"Under the supervision of Mr. McDaniel drilling has been commenced and a hole sunk to the depth of 127 feet, using a 3¾ inch by 2½ inch by 3-foot bit [probably a misprint, as a 5-inch bit was used], operated by a hand power spring pole and duplex block attachment. The first oil sand occurred at a depth of 62 feet and continued through 6 feet to a depth of 68 feet. From this stratum, using the mud bailer as a pump, 46 gallons of crude oil of an excellent quality was secured in one day's work, and samples sent to the Government laboratory at Manila for analysis. The analysis is given at the conclusion of this article. Owing to the crumbling nature of the formation above and below, this oil-bearing stratum was cased out and the well drilled to its present depth of 127 feet and the casing extended down to 103 feet. The second oil stratum was found at a depth of 117 feet extending downward 5 feet or a depth of 122 feet. The yield of oil of this depth was practically the same as that of the first stratum, but a satisfactory pumping test could not be carried out with the mud bailer, there being no other appliance at hand.

"From hydrometer tests made in the field by Mr. McDaniel with thermometer at 32° C, and clear water specific gravity at .9995 the sample of crude petroleum from the 62-foot depth showed a specific gravity of .803. A sample of petroleum from a can of the Comet brand at the same time showed a specific gravity of

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.8005. Sample of oil from the 127-foot depth, with thermometer at 29° C., showed specific gravity was .803 and a sample of petroleum from a different can of the Comet brand at the same time showed .801.

"An analysis of the oil from the Bayhay field (the sample being taken from the 62-foot stratum) made by the Bureau of Science, Government laboratory in Manila, during April, 1906, shows the following report on analysis of crude petroleum. Specific gravity of original sample 30° fractional distillation; A, 90°—150° C.= 6 per cent of 49° Bl.; B. 150°—300° C.= 67.5 per cent (B refractionated); B. I, 150°—185° C.=20 per cent of 44° Bl.; B. II, 185°—250° C.= 28.5 per cent of 35° Bl.; B III, 250°—300° C.= 19 per cent of 27° Bl.; C, fraction not boiling at 300° C. was redestilled in vacuum (6 to 8 mm. pressure); 170°—300° C.= 23 per cent of 18° Bl. per cent; D, residue of tar, etc. =3 per cent. (Signed, Herbert S. Walker, Analyst.)"

Another small well was driven by Mr. Cook on the Vigo river to a depth of 70 feet and a small showing of oil obtained.

A short report on this district was made by Geo. I. Adams, geologist, Bureau of Science, in 1909.

In January Mr. Wallace E. Pratt and myself made a hasty examination of the geology of a section of Tayabas from Catanauan to San Narciso and from Mantataja to Cabuajan. The most important feature of this examination was the discovery of an outcrop of igneous rock near the Vigo River and another at a point eight kilometers west of San Narciso. This discovery makes it very doubtful if much oil can be found on the east coast, although it is impossible to tell just how much of the country is affected. There have been large oil fields in the United States found within a mile or two of igneous rock. The effect of igneous rock is shown in figure 3, which represents in part the probable condition at the Vigo River. Here the igneous rock has come up through the sedimentaries breaking and bending them, finally standing up as a high cliff easily seen from the river.

The northern outcrop west of San Narciso is a small showing sticking up through the *cogon* grass west of the coast range of mountains. It appeared to have been exposed by the weathering away of the shales surrounding it. The line joining these outcrops is parallel to the coast, from which one might infer that the eastern coast range was raised by the igneous intrusion. This is further strengthened by the fact that igneous rocks are also found to the north at Peris and to the south near the point of the peninsula, but none has ever been reported in the interior.

The sedimentaries which occur in this area are of tertiary age and consist of shales, sandstones, and limestones. The shales are for the most part much folded and twisted and seem to underlie the sandstone and limestones.

The section from Mantataja to the Vigo showed two synclines, an anticline in the middle and a monocline or section of an anticline at each

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end as represented in figure 3.

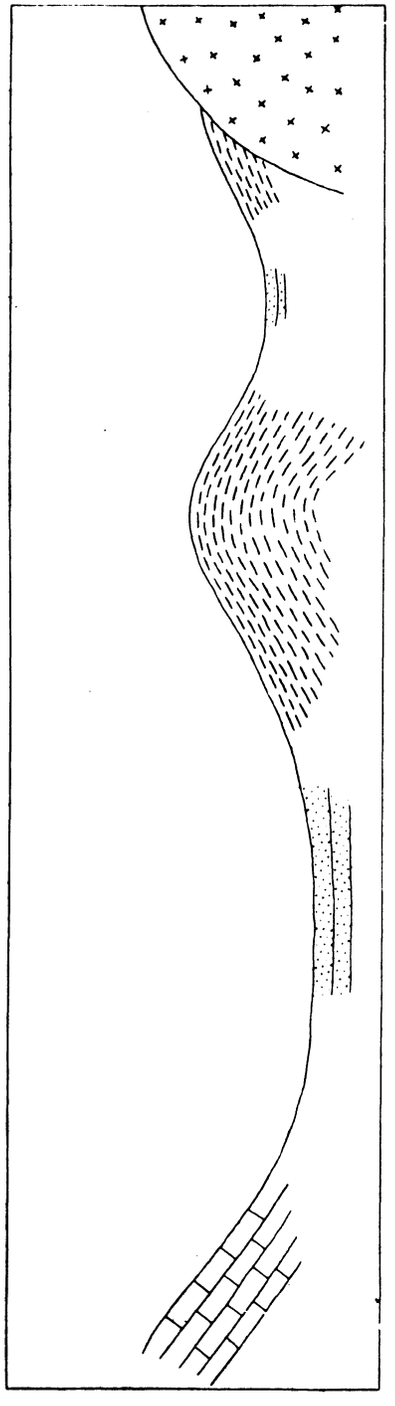

FIG. 3.—Possible section from Montataja to the Vigo River.

On the west are limestones dipping 45° to the east, followed by almost flat beds of sandstone, then shales dipping about 30° to the west. From this point several minor folds seem to occur until Cabuajan is reached, which is in another syncline with shales on the west dipping 45° to the east, flat beds in the center, and on the east shales and sandstones dipping 45° to the west. On the northern part of the *barrio* are shales striking east and west and dipping 40° to 50° to the south as if forming another anticline.

Farther south toward the Bayhay the formation changes to massive beds of limestone and sandstone dipping about 5° to the southeast, and striking about N. 35° E. These beds continue for miles to the south and east and present a beautiful formation for oil accumulation, if that below is similar. However, they seem to overlie the folded shales in such a way as to indicate an unconformity (Fig. 4). Therefore, the strikes and dips of the beds would be no indication of the strikes and dips of the oil bearing sands below. It is a characteristic of the rest of the district, also, that almost all the high points are composed of beds of sandstone and limestone. At San Narciso this is particularly well shown. The sandstone and limestone cover the ridge to the west, dipping with the slope of the ridge, forming a syncline in the bay and again rising and covering the ridge on the San Narciso peninsula.

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However, if the assumption is correct, that the coast range was raised by the intrusion of the igneous, it would be very doubtful if the land near the coast were valuable for oil.

Oil seepages have been been found in several parts of the peninsula. One, near the Ajus occurs in shales dipping 45° to the east and striking almost north and south. Another one is reported near Bondoc on the west coast. Several have been found near the Vigo and Baybay Rivers, and one near Guinayungan. A gas blow-out was reported near the southern point of the peninsula. .

Oil seepages have been found in Pangasinan, and Tayabas Provinces, Luzon, and in Panay, Cebu, Masbate, and Mindoro. Oil has been found in paying quantities in Borneo and also in Sumatra, islands near the Philippines.

Conclusions.—Owing to the intrusion of the igneous, it would not be probable that any commercial quantity of oil would be found on the eastern ~~or western~~ coast range, for the strata nearby would be squeezed up, and possibly be deprived of their oil by pressure or heat, yet it might prove favorable to oil accumulation at a distance of a kilometer or so on account of the basin formed by the folding of the sedimentaries.

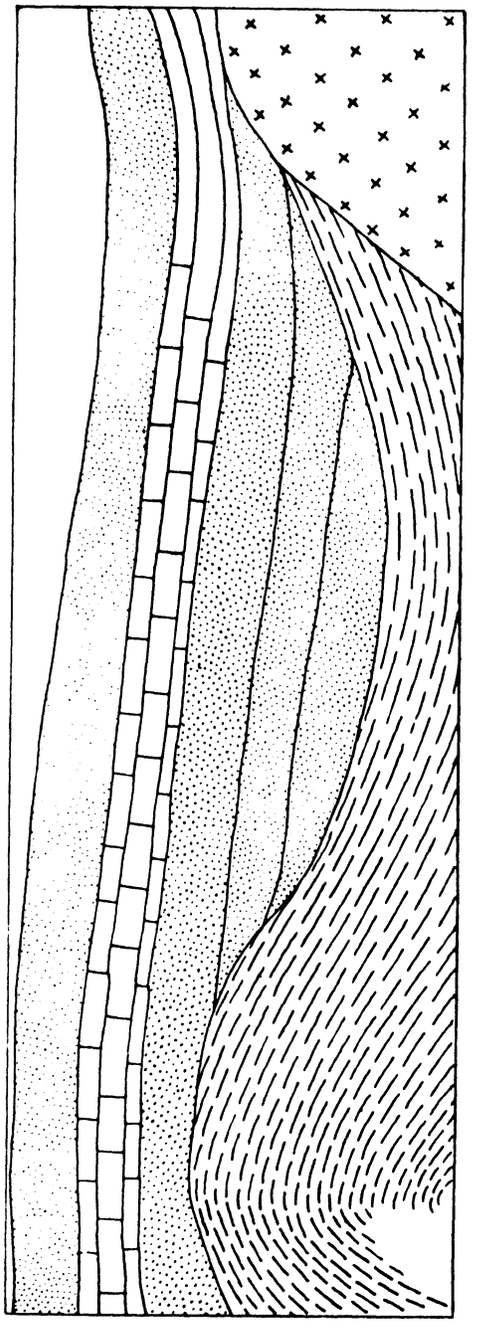

FIG. 4.—Possible section E–W.

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The oil samples from this district show oil of such a high grade that it would seem to have been refined in its upward passage through the rocks and would indicate that as yet the true oil sands have not been tapped.

The portion of the peninsula near the central anticline should prove a favorable location for a test hole.

Surface showings are as good as are usually found near large oil centers, and give as good a chance of finding oil as many of the large oil districts in the United States seemed at first to offer.

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PHILIPPINE PLACERS.

By R. Y. HANLON.

(Of Cole and Hanlon, Consulting Engineers, Manila.)

Gold-bearing alluvials have been discovered in many widely scattered localities throughout the Islands from northern Luzon to Mindanao, but, with the exception of the Paracale, Gumaus, and Malaguit districts in Camarines Province, southeastern Luzon, very few reliable data or information other than those contained in the old Spanish reports are available.

Recently the northern coast of Mindanao in the vicinity of Surigao and Cagayan has been attracting attention, and, if the reports from these places are to be credited, large areas of hydraulic and dredging ground may be developed in the near future.

The district of Nueva Ecija, some 95 kilometers north of Manila, contains thousands of acres of gravel deposits, parts of which have been examined in a cursory manner with varying results. A through examination of the field might show the existence of good pay channels or deposits, but as yet nothing other than the presence of submerged clay beds of varying thickness has been proved. Systematized drilling by the persons holding claims in the district would be a move in the right direction. The judicious expenditure of 100 dollars per annum, the assessment charge, in such work upon each group of claims in a few years' time would demonstrate sufficiently the advisability of a further retention of the property.

The Malaguit River in Ambos Camarines bids fair to become an important dredging field and, equipped with modern dredges designed to handle ground of the character encountered in the district, should yield substantial returns in the years to come. There are probably 1,200 hectares of alluvium upon the river, which extends from the sea for a distance of about 10 kilometers before the higher plateaus are reached. This area is all a tidal plain overgrown with a profusion of mangrove timber and covered with about a meter of water at high tide.

The deposit consists of a topping of loam and decayed vegetation, clay and sand, over a clean, angular gravel wash free from large boulders upon a soft to medium hard schist and granite bedrock which is quite

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irregular and prone to contain fissures. This description applies particularly to the upper reaches. The lower section possesses a soft, decomposed bedrock which is fairly regular and usually a granite.

The depth of the alluvium varies from 4 to 8 meters at the Philippine Gold Dredging company's dredge, some 6 kilometers from the sea, to 11 and 13 meters near the river's mouth. The dredge now operating upon the river is a Risdon 3.5-cubic-foot, loose connected, or link-bucket type capable of handling from 20,000 to 25,000 cubic meters per month under favorable conditions and in ground of the character for which it was designed. The actual amount being dredged per month, in the material being worked, will not exceed 18,000 and is, perhaps, nearer 12,000 cubic meters, which, on the basis of the gold won plus 25 per cent for losses, gives an actual gold content of 33 cents per cubic meter.

The approximate working cost, exclusive of depreciation, office expense, and interest on the investment, upon the above basis is 13 cents United States currency per cubic meter. Owing to the fact that no record is kept of anything other than the number of ounces of gold won per month or fortnightly, an accurate estimate of values is impossible either here or upon the Paracale dredges where the same system is in vogue.

The Paracale district, the most widely known field in the Islands and the only one, until recently, upon which any dredges had been operated successfully, is situated upon the Paracale River and several branch streams which lie beyond a ridge about 1 kilometer north of the Malaguit River, but, unlike the Malaguit deposit, the Paracale ground lies almost entirely in an elliptical basin and contains some 400 hectares of alluvium, some 120 hectares of which are located in narrow valleys leading from the basin. The deposit, with the exception of a 120-hectare coconut grove bordering the bay and the upper reaches of the streams, is submerged about 1 meter at high tide and covered with mangrove timber which appears quite formidable to one unacquainted with its characteristics, but which offers no serious obstacle to dredging and might even be considered a valuable asset as it makes excellent firewood when dried and affords the most desirable fuel for miles around at a very nominal cost, about 1.25 dollars per cord.

The deposit consists of a sticky loam over a clayey sand, sometimes quite tough, especially in the coconut plantation, underlaid by a gravel consisting in the main of quartz fragments and sand, and occasionally a small percentage of clay. The quartz fragments are small in the valleys and the upper portion of the basin, but in the lower section they are coarse, and large fragments weighing several hundred weight are at times encountered. These are saved and run through a 5-foot Huntington mill yielding an average of 15 dollars per ton in free gold. The concentrates from a Wilfley table are saved for shipment and are reputed to be worth about 100 dollars per ton.

The bedrock throughout the deposit is a soft decomposed granite or schist, schist predominating, and possesses a very uniform grade or slope

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toward the sea. The thickness of the alluvium varies from 5 meters at the upper end of the valleys to 14 meters at the lower end where the Paracale dredge is now operating.

The gold is in nugget form, coarse and fine, with an appreciable quantity of flour. It is clean and lends itself readily to amalgamation. The roughness of the larger particles indicate very clearly the local origin of the deposit, evidently by erosion from the ledges and stringers in the schists of the surrounding hills. Practically all of the values are found in the bottom wash, which ranges in thickness from a few inches to several feet.

The percentage of black sand is large, about one ton to the thousand yards, and is found in varying quantities throughout the deposit. It assays some 100 dollars per ton and might prove a valuable asset, provided economical means of saving it could be evolved.

At present there is only one dredge operating in the field, the other having been idle for the past year on account of litigation. Both these dredges are of New Zealand design and manufacture, equipped with 5-cubic-foot open connected buckets and dig on a head line. They are steam driven and of low horse power, consuming about 3 cords of wood daily. As a matter of fact, neither of the machines was designed to handle the ground being dredged and their efficiency is less than 50 per cent of the proper working capacity of 2000 cubic yards per 24-hour day.

The total area of ground excavated by the Paracale Gold Dredging Company's dredge has been about 2.4 hectares; from this they have won some 200,000 dollars. The depth has averaged about 14 meters, which would give a total handled of about 344,000 cubic meters showing an approximate saving of 58 cents per cubic meter. The extraction has been low, certainly less than 80 per cent. Those familiar with the operation of the dredge place it at about 50 per cent, but the probabilities are that 75 per cent would be more nearly correct. This would give an average gold content of 60 cents per cubic yard for the area excavated, the high average being due to the fact that a rich pocket of considerable area was encountered a year or more ago.

It is hardly to be expected that the entire district will average nearly so well, but as yet sufficient data are lacking to determine this point. However, there is every reason to believe that the entire district will prove profitable if handled by one or two large companies with sufficient capital to enable the joint installation of several large-capacity modern dredges, preferably with close-connected bucket lines and a large table area with water under high pressure. No single installation with its attendant extra expenses, which might be divided among three or more boats, can work under the conditions obtaining in that section of the Islands, for a per cubic meter cost of much less than 13 cents, but a consolidation operating three or more dredges should cut the expenses of operation to 9 and possibly to 6 cents per cubic meter.

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The greatest obstacle at present is poor transportation and terminal facilities; the next is the large quantity of sand and other disintegrated material to be washed over the tables; and the third worthy of mention is the labor problem which is always an important factor to be considered in the Philippines.

The first adverse condition could be improved readily should sufficient dredges be put in operation to warrant the service; the second could be remedied by the adoption of certain devices controlled by a certain American manufacturer.

The crying need of the dredging and other mining industries to-day is capital judiciously expended, but capital makes certain demands and stipulates certain requirements which must be conformed with before it can be expected to exploit and develop the large placer fields now lying idle throughout the Archipelago.

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COST OF MINING IN THE PHILIPPINES.

By F. T. Eddingfield.

The costs of mining can be divided into two main groups: (1) Cost of labor; (2) Cost of supplies. In any one district where the actual cost of supplies per unit, and of labor per man, are uniform, the peculiar condition of the ore, the character of the country rock, the efficiency of labor, the efficiency of the process employed in mining or milling, and the policy of the management are elements which cause variation in the total cost per ton of ore. For this discussion, data from the three principal mining districts of the Philippines have been secured, i. e.: (1) Baguio mineral district, Benguet, Luzon. (2) Paracale, Ambos Camarines, Luzon. (3) Aroroy, Masbate. I intend first to tabulate the cost of labor and supplies in these various districts and then to discuss the special characteristics referred to above.

Cost of white labor.

[In pesos Philippine currency.]

	Baguio.		Paracale, per month.	Aroroy, per month.
	Per month.	Per day.		
Superintendent	300–500		300–500	300–500
Engineers	*300		*250	*300
Mine Foreman		12	250	
Mill Foreman		15	250	
Shift bosses, mine			200	
Shift bosses, mill			200	
Mechanics		10	300	*300
Carpenters			250	
Clerks		8	150	

* Average.

Cost of native and Oriental labor.

[In pesos Philippine currency per day.]

	Baguio.	Paracale.	Aroroy.
Capatases, mine	1.40–1.50	1.50	1.50
Capatases, mill	1.40–1.60	2.50	
Shift bosses, mine	1.50		
Mechanics		2.50	
Carpenters:			
Japanese	3.00–3.25	3.00	
Natives	1.00		
Miners and muckers	0.80–1.40	*1.05	1.00
Timbermen:			
Japanese	3.50		
Natives	1.50–2.00		1.20
Pumpmen		1.25	
Hoistmen		2.00	
Blacksmiths		2.75	

* Average.

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Cost of supplies.

[In pesos Philippine currency.]

	Baguio.	Paracale.	Aroroy.
Mine timbers:			
Rough	Pine, 7 to 8 feet long, 0.10 per inch diameter.	Hardwood, 15 feet long, 0.10 per inch diameter.	Hardwood, 12 by 12 inches, 0.40 per running foot.
Framed	2.15 per set		
Fuel	Gasoline, .65 per gallon; pine, 2.50 per cord.	Native wood, 3.75 per cord; coal, Batan, 10 per ton.	Native wood, 3 per cord.
Explosives	Caps, 2 per box, dynamite, 20 per case; fuse, 2 per 100 feet.	Dynamite Atlas, 40 per cent, 650 per ton.	Dynamite, 650 per ton.
Candles	7.50 to 16.50 case	Goodman, 9	
Lumber	Lagging, 7 feet by 5 inches, 0.10 each; rough lumber, 95 per M.	R. O. pine, 65 per M board feet.	60 to 85 per M board feet.
Pipes	18 inches slip joint $\frac{3}{16}$ inch by 10 feet, 39.54; 14 inches flange, $\frac{3}{16}$ inch by 8 feet 30.25.	Small pipes, 0.25 to 0.75 per foot.	
Drill steel	$\frac{1}{2}$" to 1." 0.60 per kilo.		
Rails	7 kl. German 1.75 per meter	12 pounds T, 1.90 per foot	
Tools:			
Shovels	R. D. P. H., 1.95	R. D. P. H., 1.00	
Picks	Drifting, 2.25	Drifting, 0.75	
Hammers	3, 6, and 8 pounds, 2 to 6	4 and 8 pounds, 0.25 per pound.	
Wheelbarrows	Iron, 18.50	Iron, 11.50	
Lubricating oil	Cylinder, 2.55 per gallon	Cylinder, 1.50 per gallon	
Cement	12 per barrel	5.60 per barrel	5.60 per barrel.

From the above tables it can easily be seen that the wages paid for labor and the cost of timber cut near the properties are uniform for all the districts, but the costs of supplies vary, due to the cost of transportation from Manila to the mine. Since all supplies except lumber are imported, usually from the United States or Germany, the cost at the port in Manila is larger than in most mining districts of the United States. Add to this the high rate for transportation from Manila to the mine, and the ultimate cost becomes excessively large. The cost of transportation from Manila to the mine is almost equal to, and in one case many times greater than that between Manila and the United States.

Shipping charges from Manila to destination.

[In pesos per metric ton or cubic meter.]

	Paracale.	Masbate.	Baguio.
Machinery	4.60–5.70	3.10–3.80	60.00–70.00
Lumber	4.20–4.60	3.70–3.00	
Cement	6.70	4.80	
Ore	4.20–4.60	2.70–3.10	
Dry goods	6.70	4.80	
Canned food	6.70	4.80	
Coal	4.20	2.70	

Taking the cost of supplies alone as a basis of comparison, assuming all other conditions equal, the most expensive district for mining would

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be Baguio, the next Paracale, and the cheapest Aroroy. This condition is particularly important in considering the purchase of equipment, milling and mining machinery, for the extra cost of such equipment delivered at the mine would vary directly with the cost of transportation to the various districts. However, the total cost of supplies used in operation is rarely more than 20 per cent of the total expenses, consequently a variation of 100 per cent in the cost of supplies would cause an increase of only about 13⅓ per cent. in the total cost of operation.

INFLUENCE OF THE CHARACTER AND LOCATION OF THE ORE BODY AND THE CHARACTER OF THE COUNTRY ROCK.

The conditions affecting the variation in cost under this head are—

A. The character of the ore body—1, toughness; 2, hardness; 3, width and length of vein; 4, dip of vein; 5, character of the ore; 6, quantity of ore above the ground-water level; 7, regularity of the deposit.

B. The character of the country rock—1, toughness; 2, hardness; 3, kind and number of intrusions; 4, character of the walls of the vein.

C. Conditions in the working places as to temperature, air, and water.

D. The distance that the ore must be transported to the mill.

A and B.—In all countries the cost of breaking rock varies greatly with the toughness, on account of the amount of powder required, and the failure of the holes to break clean. In this country where the native miners have not had much experience in working hard rock the cost also varies with the hardness. However at present, most of the mines here are still working in the oxidized zone where the rock is decomposed and comparatively soft. In only a few cases has hard fresh rock been encountered. The actual cost of breaking rock in most instances varies inversely with the cost of timbering; consequently the total cost is generally less variable than the breaking cost, since a soft, easily broken rock usually requires more timber than a hard, tough rock which frequently needs none at all except in the slopes. Exceptions occur when the rock is soft, but stands well without timbering, when the rock, though hard, requires timbering, and when rock, both hard and tough, is under such pressure that it swells, needing constant attention.

In the three districts mentioned the workings are in the oxidized zone. Paracale alone reached heavy sulphides although still in the zone of oxidation. The ores are generally soft, requiring timbering in Benguet but standing well in Paracale and Aroroy. In all three districts some very hard country rock has been encountered which required no timbering.

The most favorable element is the large quantity of ore which can be developed and worked by drifts. This is more pronounced in Baguio and Aroroy than in Paracale. In Aroroy the veins follow the crest of

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ridges which are several hundred meters above sea level and have exceedingly steep sides. In Baguio the veins have no apparent relation to the topography, but are usually so high on the slopes that over one hundred meters of "backs" can be developed. In all the districts the veins are large and easily followed. Pieces of country rock called "horses" are very common in Aroroy and not infrequent in Baguio. Faulting is rare, but irregularities in the width of the vein and direction of the walls are common. Consequently, in the Philippines the ore bodies and the country rocks are in conditions most economical for mining.

C.—Great care has to be exercised as to ventilation, on account of (1) the high temperature; (2) the great humidity of the atmosphere; and (3) the growth of wood-destroying fungi in the still air of the working places. The first two influence the workman only, and regulate the amount of work one man can do, the number of men that can be employed in one working place, and the attitude of the miner in regard to his work, for in no country will a miner work contentedly for any length of time in foul air at a high temperature. The wood-destroying fungi cause the timber to rot very rapidly, but they grow only in still or foul air. A fresh strong timber has been known to rot completely in a few months under unfavorable conditions. Pitch pine is but slightly affected, however, and the first group native hard woods are also very resistant.

Water causes but little trouble in Baguio and Aroroy, but in Paracale it has been a serious element to contend with. It was found that during the rainy season the mine pump was pushed to its capacity to keep the water down, while in the dry season scarcely enough water could be obtained to feed the boilers.

INFLUENCE OF LABOR.

The number of natives who have had experience in modern methods of mining is very limited, therefore, any mine having a large output must employ a large percentage of green workmen. Furthermore the number of natives willing to work underground is small, consequently it is hard to obtain and maintain a full working force. However, this condition is rapidly becoming more favorable, for the native learns readily and can be successfully used, if handled properly. No better example could be desired than the Benguet Consolidated Mine, where the average miner works more than 20 days each month, and the millmen average 25 or more. The efficiency of this labor is surprising. On an output of only 20 tons per day with a great deal of development work and retimbering as well, the total mine expense, exclusive of milling, was less than 2.00 pesos per ton.

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Table of mine cost.

[In pesos Philippine currency.]

	Aroroy.	Baguio.		Paracale.	
		No. 1.	No. 2.	No. 1.	No. 2.
Drifting, per foot	3.10	2.00	10.00	5.00	[a] 1.00
Cross cutting, per foot	2.50	------	------	5.00	[a] 1.00
Timbering:					
Per foot drift	------	------	2.50	------	------
Per foot shaft	------	0.40	2.50	------	------
Shaft sinking, per foot	45.00	------	20.00	50.00	[b] 150.00
Raising, per foot	5.00–6.00	------	------	------	------
Milling, per ton	------	1.50	------	------	------
Fuel, per ton	------	------	------	0.56	------

[a] Contract. [b] Over.

Table of rate of work.

	Aroroy.	Baguio No. 2.	Paracale.
Tons mined per day	------	75	50–75
Feet advanced per shift per drift	------	2	1
Feet sunk per shift (shaft)	------	0.5	0.33
Feet sunk per shift (winze)	------	1	0.5
Feet raised per shift (raise)	------	1.5	1
Feet drilled per shift per man	------	7	4–6
Men per ton of ore	------	2	3–4

From the above tables it can be seen that the cost of mining and milling in the Philippines compares favorably with other countries, notwithstanding the difficulties encountered; Paracale averages higher than the other districts on account of the nature of the ore and country rock and the location of the ore body.

The policy of the mine management and the process employed in mining or milling are subjects which require no special discussion in reference to the Philippines. However, it is well to note that the Filipino does not differ materially from other races in that he responds to good treatment, and is more contented and works better when provision is made for his comfort and recreation. This also particularly applies to Americans employed at the mine, for the climate and conditions here are not such as to stimulate labor or promote contentment.

The total labor cost of mining was obtained for only three mines.

Cost of mining, milling, etc. at Baguio and Paracale.

[Figures in pesos per ton.]

	Baguio.		Paracale.
	A.	B.	
Cost of mining	1.00		9.00
Cost of milling	1.00	9.13	2.00
General and administration cost	1.00		2.00
Total	3.00	9.13	13.00

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The first example from Baguio is exceptional and in no way characteristic of the costs of the district, but since the output of this mine is only 20 tons per day, it indicates the possibilities of low cost with a large output.

The last item of cost is the disposal of the product. The all-sliming cyanide mills now being erected will produce gold bars, consequently the disposal of the product is very simple. In the past, however, two mines have concentrated their ores and shipped the concentrate, a method which will still have to be used with certain ores.

Costs for shipping concentrates.

[Figures in pesos per ton.]

	Benguet Consolidated, Baguio, Benguet.		San Mauricio, Paracale District, A. C.	
Transportation	Antamok to Baguio	15.00	Mine to dock	0.80
	Baguio to Camp 1	30.00	Loading steamer	0.80
	Camp 1 to Manila	10.00	Freight to Manila	4.20
	Handling Manila	2.60	Lighterage Manila	3.00
	Freight to Seattle	6.00	Wharfage Manila	1.00
	Freight dock to smelter	0.86	Storage Manila	1.00
			Freight to Tacoma	6.00
Total		64.46		16.80
Treatment charge		12.00		15.00
Total charges		76.46		31.80

These figures are significant, and require no interpretation.

In general we find that the most serious condition to contend with is transportation of machinery, supplies, fuel, and concentrates; the next is the quantity of labor available; next the water problem, which ranks first in many cases; and last the unfavorable climate. The natural advantages are the size and strength of the veins, the large quantity of ore that can be worked from drifts, the favorable mill sites, and the cheapness of labor.

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ON BRIQUETTING PHILIPPINE COALS.

By WALLACE E. PRATT.

The main difficulty in using the lower grades of Philippine coals for steaming purposes is the tendency of the coal to disintegrate on heating, permitting a large proportion to drop through an ordinary grate into the ash box, unburned. Cox [1] states that in a test-run on Philippine coal, the ash after having been reburned under the boilers, showed by analysis 62.6 per cent combustible matter. In the same paper Cox shows that this difficulty is not entirely remedied by reducing the open space area in the grate bars because of a slight clinkering tendency which interferes with the draft.

If this coal could be made to retain its form in lumps of suitable size, its steam producing efficiency would be increased materially. The possibility is at once suggested of briquetting the coal, using a binding material which will retain the shape of the briquet until combustion is more or less complete. Obviously a binder such as coal tar or asphalt which is commonly used would not accomplish this purpose, since they melt and run at a comparatively low temperature. Moreover, these products would be too expensive in the Philippine Islands to permit of cheap briquetting. The same objections apply to the use of natural resins which might otherwise be considered.

Experiments in the United States Geological Survey [2] have demonstrated that starch may be used with some advantages as a binder for coal briquet. Starch does not melt on heating but retains its form until completely volatilized. Mixed with water it forms a paste which is a splendid cementing material. The chief disadvantage in its use arises from the fact that briquets bound with starch disintegrate when wetted.

Bacon [3] thinks that in the growth of the cassava plant the Philippines have the cheapest source of starch in the world, and points out that the extraction should be inexpensive. However, from preliminary experiments, it is believed that the air-dried flour resulting from grinding the

[1] *Philip. Journ. Sci., Sec. A* (1908), 3, 301.

[2] James E. Mills. Binders for Coal Briquettes. *Bull. U. S. Geol. Surv.* (1908), No. 343.

[3] *Philip. Journ. Sci., Sec. A* (1908) 3, 93.

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roots could be used quite as satisfactorily as the purified starch for binding coal briquets.

The division of mines at the suggestion of Mr. E. Randolph Hix, coal expert, Philippine Government, has just taken up some preliminary experimental work on coal briquetting. The first results of this work are summarized in Table 1.

Table of briquetting tests.

Coal East Batan run of mine, through 20 mesh.	Binder.	Binder.	Compression, kilos per sq. cm.	Coherence of briquet.	Behaviour on firing.
		Per ct.			
Undried	None		500	Poor	Not fired.
Do	do		1,000	Fair	Disintegrated.
Dried at 105°C	do		1,000	None	Not fired.
Undried	Rice Hulls[a]	[b]10	100	Good	Retained shape well.
Do	do	15	200	Excellent	Retained shape until almost consumed.

[a] Waste product containing starch. The starch was not extracted for this purpose, the whole substance of the rice hulls went into the briquet. Rice hulls cost about 45 centavos per ton of briquets.

[b] Wt. of air dried rice hulls = 10 per cent wt. of coal with mine moisture.

The degree of coherence was judged simply from the appearance of the briquet. No standard test [1] was employed, owing to the small number of briquets made.

The briquets were fired in the laboratory on a grate of iron wires. While the conditions are not those of steam generating plants (for a practical test a quantity of briquets necessitating a briquetting machine for their manufacture, would be required), yet the results are valuable in showing whether or not the individual briquet burns completely or disintegrates and drops through the grate before it is consumed.

The tests without binder were suggested by the German practice in which certain lignites are briquetted in this manner, the cohesion being secured by pressure (the pressures in some plants reach 1,300 kilos per square centimeter). The lignites briquetted without binder carry a large moisture content, which is reduced by the compression in briquetting. It will be noticed that East Batan coal shows a tendency to cohere if briquetted as it comes from the mine, but if dried no coherence is obtained.

The experiments so far carried out indicate that a starch binder (the binding constituent in rice hulls is starch) hold the coal together until it is burned, thus removing the greatest objection to its use as a steaming coal.

[1] The United States Geological Survey has defined certain physical tests to be employed in testing coal briquets. The tests are made on 50-pound samples of the briquets.

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(Publication of the Bureau of Science.)

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OBITUARY

Paul Caspar Freer

DIRECTOR OF THE BUREAU OF SCIENCE OF THE GOVERNMENT OF THE PHILIPPINE ISLANDS
DEAN OF THE COLLEGE OF MEDICINE AND SURGERY AND PROFESSOR OF
CHEMISTRY OF THE UNIVERSITY OF THE PHILIPPINES, AND
FOUNDER AND EDITOR-IN-CHIEF OF THIS JOURNAL

We are deeply grieved to announce the death of Doctor Freer at Baguio, Philippine Islands, on April the seventeenth, in his fifty-first year, from arterio-sclerosis and acute nephritis.

In an effort formally to express our sorrow and to honor his memory a memorial meeting of the members of the Staff of the Bureau of Science, the Council of the University of the Philippines, and the members of the Philippine Islands Medical Association was held on July 1, 1912. The addresses delivered at this meeting were published in a memorial number of the Philippine Journal of Science.

At a meeting of the members of the Staff of the Bureau of Science, held on the eighteenth day of April, the following resolutions were adopted:

Whereas it has pleased Almighty God in His Wise and Inscrutable Providence to remove from our midst Paul Caspar Freer, M. D., Ph. D., Director of the Bureau of Science of the Government of the Philippine Islands, since the time of its organization as the Bureau of Government Laboratories in the year 1901, Dean of the College of Medicine and Surgery, and Professor of Chemistry, University of the Philippines, and Founder and Editor-in-Chief of the "Philippine Journal of Science," who, for many years, has been our Leader, Counselor, and Friend; and

Whereas at best we can do little to indicate at this time our real appreciation of him as a man and as a worker for the general good: Therefore be it

Resolved, That we, the Members of the Staff of the Bureau of Science in Manila, Philippine Islands, do hereby express our deepest sorrow and keen feeling of personal loss in the death of Doctor Freer; and be it further

Resolved, That he holds a place of highest respect, admiration and appreciation both officially and personally in the hearts of all of us, and especially of those who were most intimately associated with him in scientific work; and be it further

Resolved, That it is the sense of the Members of this Institution that the Bureau of Science has suffered a very great loss and that the cause of Science in these Islands has been deprived of one of its most zealous and conscientious advocates; and be it further

Resolved, That we extend our sincere sympathy and condolence to his Widow in her overwhelming grief, to his Sister, Brother and other Relatives; and be it further

Resolved, That copies of these resolutions be engrossed and sent to the bereaved Widow and Brother of Doctor Freer, and that they be filed in the Archives of the Bureau of Science, transmitted to the Bureau of Civil Service, published in the forthcoming Number of each Section of the "Philippine Journal of Science," in the newspapers of Manila, in a paper in the City of Chicago, Doctor Freer's birth-place, and in "Science," the Official Organ of the American Association for the Advancement of Science, of which Doctor Freer was a Fellow.

For the Staff of the Bureau of Science:

[L. S.]

RICHARD P. STRONG,
CHARLES S. BANKS,
E. D. MERRILL,
ALVIN J. COX,
OSCAR TEAGUE,
A. E. SOUTHARD,
Committee.

At Manila, Philippine Islands, this eighteenth day of April, in the year of our Lord one thousand nine hundred and twelve.

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GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF THE INTERIOR
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1911

ISSUED BY THE DIVISION OF MINES
BUREAU OF SCIENCE

WARREN D. SMITH
CHIEF

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PLATE I. EXHIBIT ROOM, DIVISION OF MINES.

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MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1911.

INTRODUCTION.

The status of the mineral industry in the Philippines at the close of the year 1911 is more satisfactory both in metallic and nonmetallic fields than at any time in the past. Extensive and careful investigation with conservative investment is the characteristic and most gratifying feature of the year's progress. Actual mining operation has been retarded by the typhoon of October, 1911, and by unsettled conditions in China, the residence of many investors in the Philippine gold and coal properties.

The following pages contain statistics of the mineral production of the Philippine Islands for the calendar year 1911, and information concerning the different mining districts up to May 1, 1912. The statistics have been gathered through the coöperation of the mining operators and the bureaus of the Government. There is always difficulty in obtaining accurate data on the production of salt, lime, clayware, etc., commodities which are the result of irregular, household industries. Each year, however, the statistics on these products become more comprehensive and reliable. The annual reviews of the different mining districts deal primarily with the local progress, but are intended to bring out also the essential general features of the districts for the benefit of readers who are not familiar with Philippine mining.

The division of mines acknowledges its indebtedness and expresses its thanks to the mining companies, the government officials, and the private individuals whose coöperation has facilitated the publication of this bulletin.

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STATISTICS OF PRODUCTION.

TABLE I.—*Mineral products of the Philippine Islands for the calendar years 1909–1911.*

[Values in pesos [a] Philippine currency.]

Products.	1907	1908	1909	1910	1911
Metals:					
Iron	(b)	[c] 17,500	[c] 31,078	[c] 20,023	[c] 29,159
Silver [d]	97	2,750			
Gold	187,647	434,500	495,194	308,860	379,906
Copper		52			600
Manganese			12,500		(e)
Total value of metals	187,744	454,802	538,772	328,883	409,665
Nonmetals:					
Coal	26,799	77,166	197,184	176,255	[f] 130,000
Clay products	(b)	421,628	422,840	430,000	450,000
Lime	(b)	20,000	69,656	70,000	90,000
Sand and gravel	(b)	206,360	325,050	293,456	477,344
Stone	(b)	149,930	311,177	372,575	655,795
Salt	(b)	(b)	375,368	380,000	550,000
Total value of nonmetals	26,799	875,084	701,275	1,722,286	2,353,139
Grand total	214,543	1,329,886	2,240,047	2,051,169	2,762,804

[a] One peso Philippine currency is equal to 50 cents United States currency.
[b] Statistics not available.
[c] Value of manufactured product, 73.0 metric tons of metallic iron.
[d] Some silver is generally found alloyed with Philippine gold; none is mined separately.
[e] No production reported for 1911, but the known deposits are receiving careful attention.
[f] 20,000 metric tons at 6.50 pesos per ton.

TABLE II.—*Comparative statement of the gold production by provinces for the calendar years 1907–1911.*

[Values in pesos [a] Philippine currency.]

Province.	1907	1908	1909	1910	1911
Ambos Camarines	4,133	143,532	216,701	144,900	198,000
Mountain Province	160,699	278,474	256,400	95,960	66,406
Sorsogon (Masbate)	22,815	1,330			70,500
All other provinces		11,164	22,093	68,000	45,000
Total	[b] 187,647	434,500	495,194	308,860	379,906

[a] One peso Philippine currency is equal to 50 cents United States currency.
[b] The total gold production for 1907 has been erroneously stated as 141,194 pesos in the past.

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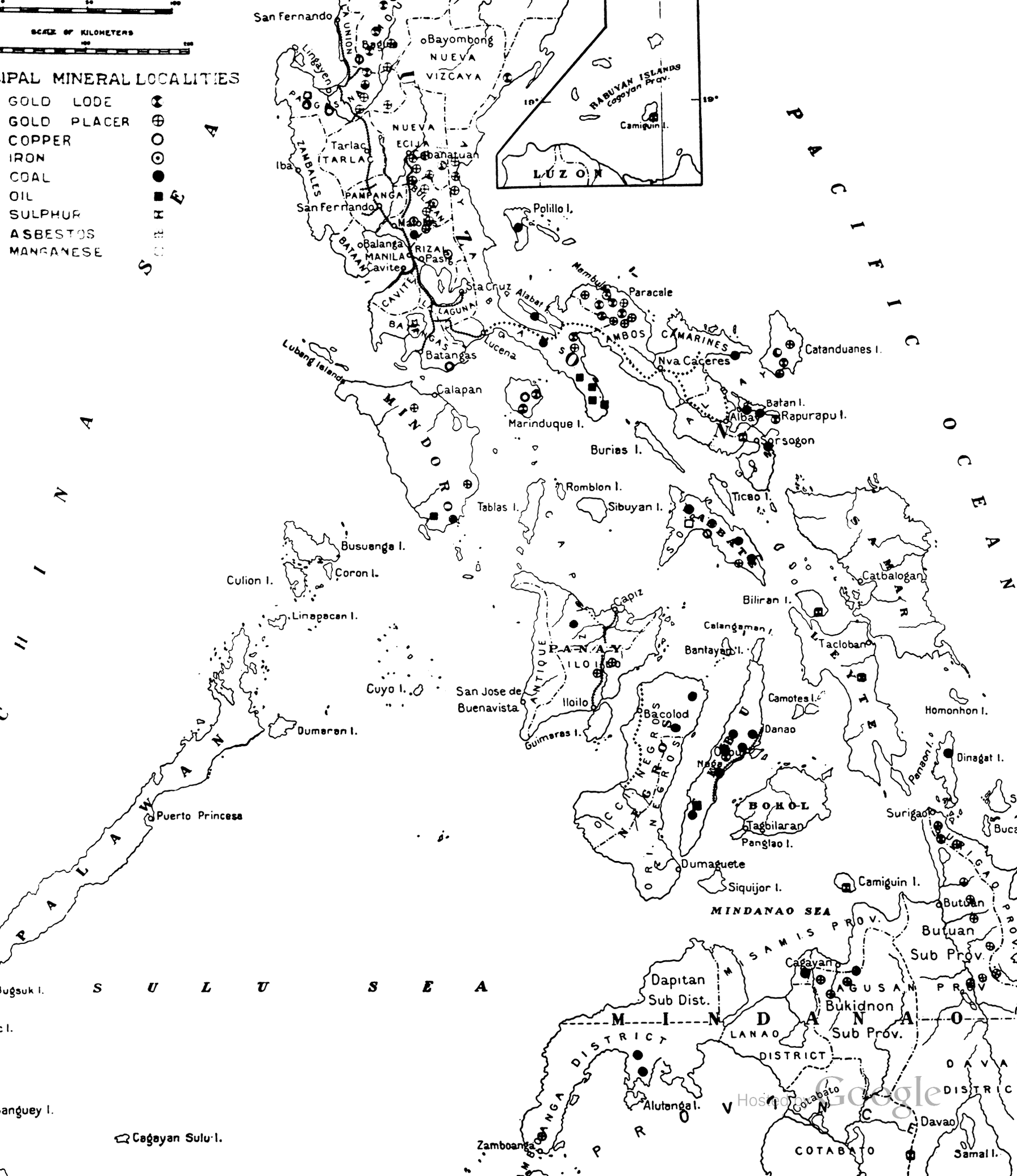
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IPAL MINERAL LOCALITIES
GOLD LODE
GOLD PLACER
COPPER
IRON
COAL
OIL
SULPHUR
ASBESTOS
MANGANESE
RABUYAN ISLANDS
Cagayan Prov.
Camiguin I.
LUZON
San Fernando
Bayombong
NUEVA VIZCAYA
Tarlac
TARLAC
Iba
ZAMBALES
PAMPANGA
San Fernando
Balanga
MANILA
Cavite
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Capiz
Biliran I.
Calangaman I.
Tacloban
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ILOILO
Bantayan I.
Cuyo I.
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Bacolod
Camotes I.
Homonhon I.
Dumaran I.
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Davao
Zamboanga
COTABATO
Samal I.
Cagayan Sulu I.
SULU SEA
PACIFIC OCEAN
SULU SEA

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SUMMARY OF THE MINERAL INDUSTRY OF THE PHILIPPINE ISLANDS FOR 1911.

The production of minerals in the Philippine Islands does not show a marked increase over that of the preceding year, still there has been a steady advance in the industry. It has been proved beyond doubt that the Philippines are potentially rich in economic minerals.

The experience of the past year has shown more clearly than ever that one of the most serious handicaps to the Philippine mining industry is the difficulty in obtaining adequate capital.

Gold.—Progress in gold mining has been much interfered with by severe storms, but certain distinct advances have been made. Large companies have been formed and several new dredges are being built.

The first marked success in gold mining and milling has been attained at the Colorado mine in Masbate.

Iron.—In the iron fields of the Eastern Cordillera of Luzon, native mining and smelting continues as in past years. The existence of these magnetite and hematite deposits, together with the more promising one of hematite near Mambulao, Ambos Camarines, has caused considerable interest recently among capitalists, who are investigating the possibilities of these natural resources.

Coal.—The East Batan Coal Company mine has been in operation throughout the year. In Polillo development work is being done on two properties, one on the Guinibauan River and another on the Anabauan River. The arrival in Manila of the Otto gas-producer plant, ordered for the Bureau of Science and especially designed for utilizing Philippine coal, marks an event of importance in the coal industry here.

Cement, etc.—Several localities have been examined during the year by companies contemplating the manufacture of Portland cement. Complete field and laboratory investigations with burning tests have shown exceptionally favorable materials and locations. The increasing consumption of structural materials and road metal has resulted in a remarkable advance in

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the quarrying industry, while the manufacture of sugar *tenajas* and brick for sugar ovens by the native clay-workers has experienced unusual growth.

Some resources, the development of which is promising and which would greatly benefit the Philippine Islands, are the following:

(1) The Cebu, Sibuguey Bay (Mindanao), and Polillo coal fields.
(2) The manufacture of Portland cement.
(3) The manufacture of sand-lime brick.
(4) The iron deposits in Mambulao Bay, Ambos Camarines.
(5) The oil field of Tayabas.
(6) The manufacture of vitrified brick.
(7) The various sulphur and salt deposits.
(8) The asbestos deposits of Ilocos Norte.
(9) The lead deposits of Batangas Peninsula.

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THE AROROY MINING DISTRICT, MASBATE.

By PAUL R. FANNING.

The production of gold in the Aroroy mining district, Masbate, showed an increase from practically nothing in 1910 to 72,500 pesos in 1911. In 1910 no mills operated, while in 1911 the Colorado mill began operations and the Tengo mill resumed work for a short time.

The completion of the Colorado mill and the beginning of successful work in October, 1911, is one of the most important events in the history of mining in the Philippine Islands. This mine is now averaging 60,000 pesos per month, which if continued throughout 1912 will give a production of some 720,000 pesos, or over double the total gold output of the Philippines during 1911. As the amount of ore blocked out or indicated is large, there is reason to feel confident that this large production will be maintained for many years to come.

The production by companies is given in the following table:

Production of the Aroroy district.

Company.	Pesos.
Colorado Mining Co	70,500
Tengo Mining Co	2,000
Total	72,500

COLORADO MINING COMPANY.

During the first part of 1911 the Colorado Mining Company continued active development work to prepare the mine for the 20-stamp cyanide mill which was nearing completion. During 1911 the mill operated irregularly for less than two months, but steady production did not begin until the last of December.

THE MINE.

An accurate description of the mine and ore bodies has already been given by Eddingfield.[1] The vein averages 4 meters in

[1] *Min. Resources P. I. for 1910, Bur. Sci., Div. Min.* (1911), 10.

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width, strikes south 45° east, and dips 70° to the northeast. The vein matter consists of quartz with some calcite and manganese. The ore is stated to average 20 pesos per ton.

The inclined shaft now reaches a depth of 146 meters, which is the greatest depth penetrated in the district, perhaps in the Philippine Islands. As stated by the company, the average values show only a nominal decrease from the top to the bottom of the shaft, and the bottom ore is said to have a value of more than 16 pesos per ton. It is to be noted that this ore is still above the level of the permanent ground-water, and hence in the oxidized zone. The indications are that the zone of oxidation should extend to a depth approximately equal to the level of the Guinobatan River; that is, 100 meters below the present bottom of the shaft. It is probable that pay ore will be found to this depth, and it is possible that the zone of oxidation may extend to an even greater depth. Whether or not a zone of enriched ore will be found at this depth is too problematic for present consideration, although the presence of manganese in the ore, as has been repeatedly pointed out, is highly suggestive of a zone of richer ore close to the level of the permanent ground-water.

The mine has been opened up by means of two main adits, 53 meters apart vertically; the upper, or No. 1, adit is 30 meters below the highest point in the outcrop. Two intermediate levels have been run, and various cross-cuts and up-raises put in. During 1911, a drift was run next to the hanging wall parallel to and connecting with No. 1; the main, or No. 2, adit was continued 80 meters farther to the northwest; the upper intermediate level was run for a distance of 120 meters; the lower intermediate level was run for a distance of 180 meters; and the shaft was sunk 30 meters to a total depth of 146 meters. In all some 800 meters of work was performed, besides preparing the ore bodies for stoping.

In stoping the ore, the square-set system of mining has been used, but owing to the high cost of timbering it is probable that some modification of the method will be adopted. The mine is surrounded by a forest of magnificent hardwood trees, but the cost of cutting, transportation, and dressing is very high. The tangle of underbrush and vines requires an extra amount of work to fell the trees after cutting and the wood is so hard that the natives saw it with difficulty. The sets are framed by hand and are so heavy as to require several men to handle each piece. The shipment of dressed pine from the United States to supplant native timbers is being considered as an economical measure.

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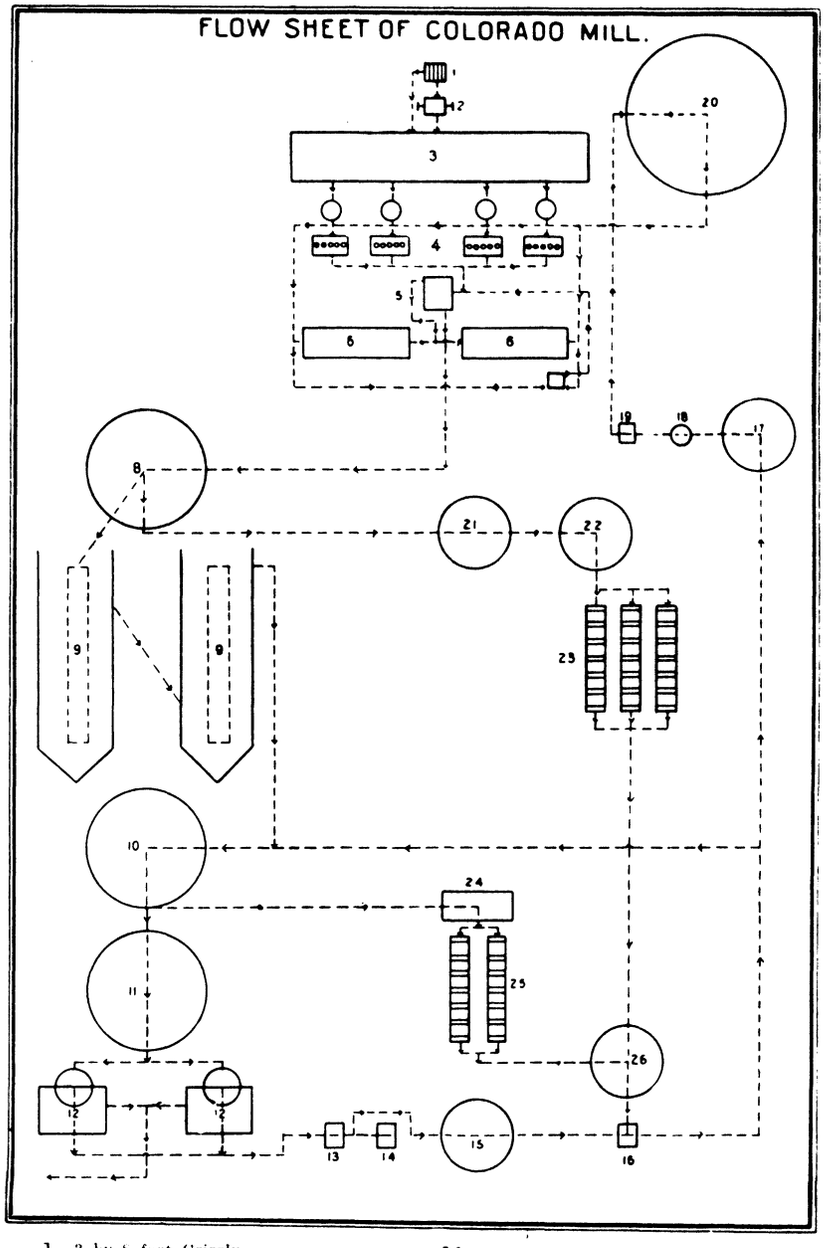

1	3 by 8 foot Grizzly.
2	10 by 20 inch Blake crusher.
3	ore-bin.
4	20 stamps; Challenge feeders.
5	Dorr classifier.
6	two 5 by 18 foot tube-mills.
7	bucket elevator.
8	28 by 14 foot Dorr thickener.
9	two 12 by 40 foot Pachuca tanks.
10	28 by 14 foot Dorr thickener.
11	20 by 8 foot Traylor agitator.
12	two 11 by 6 by 8 foot Oliver filters.
13	wet vacuum pump.
14	dry vacuum pump.
15	12 by 10 foot solution tank.
16	5 by 8 inch Triplex pump.
17	20 by 8 foot solution tank.
18	6 by 6 foot overflow tank.
19	5 by 8 inch Triplex pump.
20	28 by 14 foot storage tank.
21	10 by 10 foot clarifying tank.
22	10 by 12 foot gold-solution tank.
23	three sets 7-compartment zinc boxes.
24	clarifying box.
25	two sets zinc boxes.
26	20 by 8 foot Barren solution tank.

PLATE III.

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THE MILL.

The 20-stamp cyanide mill is of Traylor design and is of the all-sliming type, crushing in cyanide solution. The striking feature of the practice is that the gold solutions from the Dorr thickner pass to the zinc-boxes without filtering in the Oliver filters.

The ore is delivered from the second level of the mine to the storage bins, and thence to the mill by means of a 2-bucket aerial rope tramway 320 meters long.

Crushing.—The ore from the buckets passes to a 3 by 8 foot grizzly; the oversize is crushed in a 10 by 20 inch Blake crusher and passes to the bin. The ore is fed into four 5-stamp batteries by Challenge feeders. Lime, which is prepared in a kiln near the mine from a local deposit of calcite ore, is added at the batteries. The 20 stamps, weighing 1,250 pounds each, drop at the rate of 100 per minute; the height of drop is about 8 inches, and a 4-inch discharge is used. The ore is crushed in solution of a strength varying from 0.12 to 0.20 per cent potassium cyanide. A capacity of 4.5 tons per stamp per twenty-four hours is obtained when a 6-mesh screen is used. The pulp, which has a thickness of about 6 parts of solution to 1 of ore, passes to a Dorr classifier where the sands are raked out and delivered to two 5 by 18 foot tube mills. These mills are of Traylor manufacture, with trunnion bearings and spiral fed. A speed of 28 revolutions per minute is used. The lining is of the El Oro type. At first Danish pebbles were used entirely, but at present some of the harder quartz from the mine is added. The discharged pulp, which contains about 40 per cent moisture, passes to a bucket elevator and is returned to the Dorr classifier.

Screen tests showed the following:

Screen tests.

Screen mesh.	Tube-mill discharge.	Classifier sands.	Classifier slimes.
	Per cent.	*Per cent.*	*Per cent.*
On 10	0.14	0.85	none
On 20	1.53	10.05	none
On 40	8.52	19.50	none
On 60	31.29	25.55	none
On 80	19.33	14.85	none
On 100	15.32	12.25	none
On 150	7.55	5.70	6 to 12
On 200	5.80	0.65	8 to 16
(-) 200	10.52	63.00	remainder

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It can be seen that the classifier collects 63 per cent of (–) 200-mesh product along with the sands. This is poor classification and results in extra tube-mill work. However, the advantage of using a classifier, which delivers a thick product for the tube-mill, compensates somewhat for this disadvantage.

Treatment of the slimes.—The slimes, having a thickness of about 9 to 1, pass from the Dorr classifier to a 20 by 14 foot Dorr thickener. The overflow from the thickener passes to a clarifying tank, thence to a gold-solution tank, and thence to 3 sets of 7-compartment zinc-boxes.

The pulp from the thickener passes to two 12 by 40 foot Pachuca tanks connected in series. The central columns of the Pachucas discharge at the surface, and an air pressure of about 32 pounds is used. The solution has a strength of from 0.12 to 0.20 per cent potassium cyanide, and the pulp has a thickness of about 1.5 to 1. After agitation in the Pachucas, the pulp passes by launder to a second Dorr thickener. Previous to entering the thickener, the pulp is diluted with solution from the Oliver filters. The overflow from the thickener passes to a clarifying box, and thence to 2 sets of 7-compartment zinc-boxes. When first operated the thickeners gave trouble owing to the great amount of slimy foam which overflowed with the gold solution. This difficulty was overcome by removing alternate bolts on the rim launder and drawing off the solution just below the surface free from foam. The foam is drawn off separately by a central launder and passes to the Traylor agitator.

The pulp from the thickener passes to a 20 by 8 foot Traylor agitator, which prepares the pulp for two 11 by 6 by 8 foot Oliver filters. From the filters the gold solution passes by means of wet and dry vacuum pumps to a 12 by 10 foot storage tank. From here part of the solution is pumped to dilute the pulp entering the second Dorr thickener, and the remainder is relayed to the 28 by 14 foot solution storage tank at the top of the mill. None of the solution from the filters passes directly to the zinc-boxes.

Solution of the gold.—As noted, a feature of the practice is that the gold solution is taken from the Dorr thickener for precipitation rather than from the Oliver filters. The reason for this lies in the fact that about 80 per cent of the gold goes into solution before the pulp reaches the Pachucas. It would seem from this that the greater part of the gold is very fine, easily liberated, and readily attacked by the cyanide solution.

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The presence of manganese probably has been instrumental in producing this condition of the gold. Some coarse gold and gold bound up in the minerals are present, and the Pachucas give the added time necessary for their solution.

Precipitation and clean-up.—A general clean-up is made every two weeks, and the bullion is melted once a month. The zinc fines are treated with sulphuric acid, and the gold slimes are washed, steam dried, and melted in a gasoline, tilting, crucible furnace. The bullion is shipped to Manila, where the International Banking Corporation advances value based on the company's own assay. The bank ships the bullion to San Francisco, and later makes adjustments with the company.

Cost of operation.[2]—The cost of mining and milling at the Colorado Mine has been placed at less than 8 pesos per ton, and there is some reason to believe that this figure will be reduced under the conditions of steady operation. The fact that the cost of mining is moderately low would lead to the belief that, considering his low salary, the Filipino is an efficient miner. It is to be remembered, however, that the vein is of such width as to permit stoping on an economical scale. Furthermore, most of the ore is sufficiently soft and fractured so as to be readily mined without the use of dynamite. On the other hand, the cost of general supplies is somewhat high, although lower than at many mines in the United States not situated directly on a railroad. The anomalous condition of having a timber problem in the midst of a great forest has already been discussed, and this problem will become more acute as the more adjacent trees are removed.

Owing to the excessive cost of the mill, the original investment is very large in comparison with the capacity, and this means a higher cost per ton than usual owing to the factors of depreciation and interest. For this mill these two factors alone mean a cost of about 1 peso per ton, and it is possible that this amount has not been included in computing the total cost of operation.

It was the belief of the writer when first coming to the Philippines that the depreciation for this country would be especially high, and experience in many cases has justified this belief. However, there are instances where, under good construction, the depreciation has been no greater than in the United States. The destruction of buildings under the attacks of white ants or other insects does not always seem a serious consideration, as

[2] For a complete discussion of costs, see Eddingfield, *Min. Resources P. I. for 1910, Bur. Sci., Div. Min.* (1911), 10.

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there are numerous buildings, properly constructed, which have lasted for many years; certainly many years longer than the probable life of any mine. It is also known that white ants do not attack timbers which vibrate under the shocks of machinery. The construction work on the Colorado mill is of such order that it appears unnecessary to allow an excessive depreciation charge.

THE EASTERN MINE.

The Syndicate Mining Company which holds a bond and lease on the Eastern Mine continued active development work throughout 1911, and by the end of the year had greatly increased the actual ore in sight. The workings of the mine, and the character of the ore, have already been accurately described, and as stated by Eddingfield,[3] the mine "presents a possibility of having over 100,000 tons of ore averaging 9 to 10 dollars per ton."

The development work has now reached the stage where it would seem that the erection of a mill is warranted. In conformity with this plan, a sample of ore was submitted to the division of mines, for testing, and the results obtained were most encouraging. Through the kindness of Judge Geo. N. Hurd the results of these tests are here given in brief.

TESTS ON EASTERN ORE.

The ore.—The ore consists of quartz and calcite with some manganese (wad, oxides, etc.). Sulphides are subordinate. The value of the sample is 54 pesos per ton.

Amalgamation test.—At 20-mesh, 16.4 per cent can be saved by amalgamation where stamps and outside plates are used.

Concentration test.—At 20-mesh the ratio of concentration was 100 to 1. There appears no benefit nor object in concentration on this type of ore.

Cyanidation tests.—At 20-mesh, division was made into sands and slimes, and the slimes showed a high extraction. With the sands, only a moderate extraction was obtained.

Screen test at 20-mesh.

Products.	Weight.	Gold.	Assay.
	Per cent.	*Per cent.*	*Pesos.*
20-mesh original	100	100	54.00
On 100-mesh	80.2	73.37	50.84
Through 100-mesh	19.8	27.72	76.06

[3] *Loc. cit.*, p. 14.

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This test shows that when crushing through 20-mesh, approximately 80.2 per cent can be considered as sands and 19.8 per cent can be considered as slimes. As is so generally true, the slimes assay considerably higher per ton than do the sands, although the slimes actually contain only 27.72 per cent of the gold.

Where the ore is crushed through 20-mesh and divided into sand and slimes the following was shown:

Cyanide tests on sands and slimes.

Products.	Assay heads.	Assay tails.	Extraction.	Time.	Strength of solution.	Consumption per ton of ore.	Method.
	Pesos.	*Pesos.*	*Per cent.*		*Per cent.*	*Pounds.*	
Sands	50.84	24.00	55.5	2 days	0.09	0.8	Leaching.
Sands	50.84	15.90	70.4	5 days	0.28	1.0	Leaching.
Slimes	76.06	6.70	88	12 hours	0.26	0.8	Agitation.

It is apparent from the above table that a much better extraction can be obtained on slimes.

The ore was next put through 100-mesh by means of a tube-mill and the following tests were made:

Fine-grinding cyanide tests—ore through 100-mesh.[a] *(Showing effect of time.)*

Assay heads.	Assay tails.	Extraction.	Time.	Ratio of solution to ore.	Strength of solution.	Consumption per ton of ore.
Pesos.	*Pesos.*	*Per cent.*	*Hours.*		*Per cent.*	*Pounds.*
54.00	13.60	74.4	1	1 : 1	0.28	0.5
54.00	10.00	81.5	2	1 : 1	0.28	0.8
54.00	6.60	87.7	4.5	1 : 1	0.28	0.8
54.00	6.60	87.7	6	1 : 1	0.28	0.8
54.00	6.20	88.4	16	1 : 1	0.63	0.8

Fine-grinding cyanide tests—ore through 100-mesh.[a] *(Showing effect of thickness of pulp.)*

Assay heads.	Assay tails.	Extraction.	Time.	Ratio of solution to ore.	Strength of solution.	Consumption per ton of ore.
Pesos.	*Pesos.*	*Per cent.*	*Hours.*		*Per cent.*	*Pounds.*
54.00	6.60	87.7	22	1 : 1	0.28	0.8
54.00	4.24	92	22	2 : 1	0.26	0.8
54.00	4.00	92.6	22	3 : 1	0.26	0.8
54.00	3.20	94	22	4 : 1	0.26	0.8

[a] The ore was agitated in bottles, and in all cases lime was added.

As shown by the first table, the extraction increases from 74.4 per cent in one hour to 87.7 per cent in six hours. Further time increases the extraction only a slight amount. As shown

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by the second table, the extraction increases from 87.7 per cent in a 1:1 pulp to 94 per cent in 4:1 pulp.

To ascertain the effect of amalgamation previous to cyanidation, a split of the same tube-milled sample was amalgamated and showed 44.4 per cent extraction by amalgamation. The tailings were then cyanided without further crushing and showed 95.4 per cent extraction in twelve hours where the strength of solution was 0.26 per cent KCN and the ratio of solution to ore was 3:1. The consumption in this test was 0.4 pound of cyanide per ton of ore. The conclusion is that amalgamation previous to cyanidation will give a greater extraction in the same time; or, in other words, will give the same extraction in less time.

The ore was next put through 150-mesh by means of a tube-mill, and cyanide tests gave the following results:

Fine-grinding cyanide tests—ore through 150-mesh.

Assay heads.	Assay tails.	Extraction.	Time.	Ratio of solution to ore.	Strength of solution.	Consumption per ton of ore.
Pesos.	*Pesos.*	*Per cent.*	*Hours.*		*Per cent.*	*Pounds.*
54.00	3.20	94	12	2 : 1	0.26	1.6
54.00	1.82	96.6	12	2 : 1	0.26	1.2

As shown by this test from 94 per cent to 96.6 per cent extraction can be obtained when the ore is put through 150-mesh, whereas about 90 per cent is obtained under the same conditions when the ore is put through 100-mesh.

It is evident from these tests that the ore is well adapted to cyanidation where the all-sliming process is used. It has been shown that greater than 90 per cent extraction can be obtained, that the time required is moderate, and that the consumption of cyanide is low.

In view of the tonnage developed and of the high extraction possible with a suitable mill, it would seem that this mine is in a position to command the capital necessary for the erection of a plant.

OTHER PROPERTIES.

The Tengo Mining Company did a little development work and operated the mill for a few days during which some 2,000 pesos worth of gold was recovered by amalgamation alone.

It is now fairly well established that the ores of the district require a large outlay of capital before successful production can begin, and the splendid returns from the Colorado mill will undoubtedly make the securing of capital a far easier task in the future than it has been in the past.

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THE PARACALE DISTRICT.

By F. T. EDDINGFIELD.

Gold dredging seems to have fulfilled the prediction made last year by Fanning.[1] The gold produced by dredging in 1911 shows an increase of about 50 per cent over 1910 and an increase of 16 per cent over the entire production of the district in 1910.

Gold production.

[Values in Philippine currency.]

Years.	Dredging.	Quartz mining.
	Pesos.	*Pesos.*
1910	128,505	43,395
1911	198,000	.....

During the year 1911 the Stanley dredge, the Tumbaga Mine, and the San Mauricio Mine were not operating, so the entire production has come from the Paracale dredge and the one on the Maliguit River operated by the Heize Dredging Syndicate.

The Paracale Bucket Dredging Proprietary, Limited, backed by Australian capital, has been organized to take over the property of the Paracale Gold Dredging Company. They have continued operating the old dredge and have started building a much larger one, which is to be of the close-connected type with buckets of 5 cubic feet capacity. It will be operated without a screen in accordance with the latest Australian practice. The buckets dump into a box into which a strong jet of water is played to break up the cemented sand and clay. From the box all the material flows over the tables. It is claimed that the clay and cemented sand is further broken up by the bumping and grinding action as the material passes over the riffles.

Several dredges in Australia, which were unable to pay dividends while using screens, proved very profitable when the screens were removed and the entire material allowed to flow over the tables. With this modification it is said that the dredges handle more material and save more gold.

[1] *Min. Resources P. I. for 1910, Bur. Sci., Div. Min.* (1911), 18.

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The pontoon for the new Paracale dredge is being built of native hard-wood cut and sawed on the property, the two classes of wood used being *malapajo* and *palansalan.* The latter wood is said to be remarkably good for under-water service. Rough calculation shows that this wood can be obtained for about 35 pesos per 1,000 board feet.

The dredge at present working at Paracale digs up each day several tons of quartz fragments, many of which contain visible gold. These are sent to a mill built on the south side of the river. At the mill the ore is crushed partly by hand, then run through a small jaw-crusher, and elevated by a bucket conveyor to the ore bin. From the bin the ore is fed into a 5-foot Huntington mill and thence passes over amalgamation plates. The tails are concentrated on a shaking table and the concentrates are shipped to Australia. The quartz is so hard that difficulty is encountered in crushing with this machinery. A larger crusher followed by stamps would prove a good installation.

A dredge is also being built by the Philippine Exploration Company at the Gumaus property. This is a 5.5-cubic-foot Empire steam-driven dredge with wood hull and framing designed by the New York Engineering Company. It is of the close-connected bucket type with screens and stacking ladder and will be held against the working face by "spuds," one steel and one wood. The pontoon is made principally of pine. It will be interesting to compare the durability as well as the efficiency of this dredge with the new dredge of the Paracale Bucket Dredging Company.

The Gumaus property is not very heavily wooded, and it is not improbable that wood for fuel will be somewhat expensive. The ground is said to average 1.04 pesos per cubic meter and to vary in depth from 8 to 20 meters. The gold in this deposit differs from the Paracale gold in being generally in rounded grains showing practically no crystallization. It is light yellow, and seems to be singularly free from iron stain. There is also more uniformity in the size of the grains and a smaller percentage of fine gold.

Since the closing down of the San Mauricio and Tumbaga Mines, the majority of prospectors have left Paracale for other fields. However, Mr. La Duc has been working steadily on the Navotas group and has sunk several shafts on small stringers. The main shaft is of 2 compartments, well timbered; a bucket running on guides is used for hoisting. A good head-frame has been erected over the shaft and a Mundy hoist has been installed. It was reported that the stringers though small are very rich in

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gold. The property is situated almost directly west of Paracale and can be reached from there in about one and one-half hours.

Southwest of Paracale, on Mount Togas, are a large number of veins striking northeast and southwest. They show evidence of having been extensively worked in the past by natives. Two years ago Mr. Samoza worked an *arrastra* at this place for a short time. Mr. Lafferty is now prospecting these veins and has uncovered some good-looking deposits. Rumor tells of an exceedingly rich vein in this section which the old natives called the *Insic* (the Tagalog word for Chinaman) lead, because the gold in the ore is shaped almost like the Chinese eye. It is not impossible that this vein exists, as well as other rich ones, for the district of Paracale has never been properly prospected. Prospectors have been generally content with opening up the old native workings and doing little new work.

The Heize Syndicate is still operating successfully with a dredge on the Malaguit River, and steps are being taken by the Stanley Company to put their dredge in working order.

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THE BAGUIO MINERAL DISTRICT IN 1911.

By WALLACE E. PRATT.

The Baguio Mineral District,[1] located near the City of Baguio in the Subprovince of Benguet, has been discussed each year in the Mineral Resources of the Philippine Islands and has been the subject of several articles in the Philippine Journal of Science. All the available data on the geology and ore deposits may be found in the articles cited in the footnote. The gold ore of this district is classed as generally low grade (10 to 20 pesos per ton) with irregular and local high values. The prevailing rock has been shown to be andesite. The veins are usually true fissure veins, with subordinate contact deposits between andesite and diorite and between andesite and sedimentaries. Quartz, calcite, and manganese characterize the vein material.

In October, 1911, the Baguio district suffered the severest typhoon in its history. New mills were severely damaged, and in some cases destroyed, on properties which had already suffered the loss of mills and other property through earlier typhoons. Mine roads were obliterated by land slides, and high water cut off all communication with Manila. While this damage was a severe blow to the district and curtailed the annual production, yet the confidence of the operating companies in the ultimate

[1] Metallic mineral resources, by Maurice Goodman. *Min. Resources P. I., Bur. Sci., Div. Min.* (1908), 22.

Metallic mineral resources of the Philippines, by Henry G. Ferguson. *Ibid.* (1909), 20.

The Baguio mineral district, by Frank T. Eddingfield. *Ibid.* (1910), 14.

Developments in the Baguio district, by Warren D. Smith. *Ibid.* (1911), 15.

Geology and geography of the Baguio mineral district, by A. J. Eveland. *Phil. Journ. Sci., Sec. A* (1907), 2, 207.

Additional notes on the economic geology of the Baguio mineral district. *Ibid.* (1911), 6, 429.

The gold deposits of the Philippine Islands, by Henry G. Ferguson. *Econom. Geol.* (1911), 6, 109.

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value of their properties is unshaken, and the recovery of the industry is already becoming evident.

That typhoons and the resulting floods are factors which must be taken into account in mining practice in the Philippines has already been pointed out by Eddingfield [2] in discussing the placer deposits of Nueva Ecija. The typhoon factor in the Baguio district is recognized by the experienced operators as extremely important and it will be given greater consideration as the district develops. Already there is a tendency to avoid the lowest terraces along the Antamok River in locating new mill sites. The older mills were built on these lower terraces, on account of the favorable steep slopes obtained, but it is probable that future mills will be located higher above the river bed, even at the expense of less favorable slopes and longer pipe lines for water power.

The gold production for the Baguio district in 1911 amounted to 66,406 pesos as compared with 95,960 pesos in 1910, 243,500 pesos in 1909, 270,600 pesos in 1908, and 155,520 pesos in 1907. The Headwaters, the Benguet Consolidated, the Major Mines, and the Camote-Clayton have contributed to the year's production.

The Camote-Clayton on the lower Antamok River is equipped with a 3-stamp battery and plates for amalgamation. Mr. Reavis who is in charge of the property has recently made an attempt at cyanidation; the tailings from the plates are sent to an improvised classifier and the sands from this to leaching tanks, whence the solution is decanted to zinc-boxes for precipitation. Power for the mill is supplied by an overshot waterwheel made on the property, water being brought down in an open flume from about 200 meters up the river. The ore comes to the mill by gravity by means of a small aerial tramway. Underground, Mr. Reavis has continued development to supply the ore milled. The vein being worked, described by Eddingfield,[3] is a calcite-manganese vein, 8 to 15 meters wide in a contact zone between andesite and diorite. There is a tendency toward banded structure of calcite and manganese. The milling ore is largely calcite, much blackened by manganese oxides, with occasional patches of lighter colored quartz, apparently less contaminated with manganese. Recent development encountered ore carrying visible gold at a point 14 meters below the lowest former workings. In the specimens exhibited, considerable free gold and some malachite can be seen in an otherwise typical ore.

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[2] *Min. Resources P. I. for 1909, Bur. Sci., Div. Min.* (1910), 26.

[3] *Loc. cit.*

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On the Major group of claims, located on a tributary of Gold Creek (Gold Creek and Antamok River are roughly parallel, separated by a high, narrow ridge, and together drain the area adjacent to the principal mines of the district), a 6-stamp Hendy mill operated during the early months of 1911. An unusually large number of veins have been found on the property, characterized, according to Smith and Eddingfield,[4] by pyrite sometimes accompanied by galena and copper sulphides, in a quartz gangue. Ore with visible free gold has been noted in some of the veins. The veins occur in andesite and sedimentaries, possibly a result of contact phenomena.

The Benguet Consolidated is located on the Antamok River and is the oldest property in the district. It was damaged beyond operation by the flood in October, 1911, which destroyed the pipe line for water power. The cyanide mill had been destroyed by the flood of October, 1909, and in the interim the stamp mill had been run under difficulties, the tailings from the amalgamating plates going to waste. The Consolidated has developed a large tonnage of ore and is considered to have a valuable asset in its possible ore reserves.

The Headwaters Mine, located on the upper part of the Antamok River, was operated only a few months after the completion of a new cyanide mill in 1911 when it was forced to close down by the flood in October. The following notes concerning the first operation of the Headwaters mill were obtained by Mr. P. R. Fanning of the division of mines, through the courtesy of Mr. F. L. Cole, who was in charge of the mill at that time.

The ore was trammed by hand from the mine to the mill, where it was passed over grizzly bars and through a Blake jaw crusher to the mill ore-bin. From the bin the ore was fed to a Hendy 10-stamp mill by Challenge feeders. The stamp-mill product was classified by an 8-foot Callow conical classifier from which the slimes went to a slimes collector and the sands to a Hardinge conical tube-mill, followed by a double cone classifier from which the slimes went to the collector and the sands were returned to the tube-mill by a Frenier sand-pump. The slimes from the collector were agitated from eight to sixteen hours in 2 Pachuca tanks, and then passed through 2 conical collecting tanks to a Ridgway filter. The solution from the filter went through a gold-solution tank to zinc-boxes from which it went to the sump for return to the head of the mill. The precipitated values were cleaned by acid and smelted to bullion in a gasoline pot-furnace. Owing to difficulty in the opera-

[4] *Loc. cit.*

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tion of the Ridgway filter, it was cut out of the process and the gold solution was decanted directly from the conical collecting tanks to the gold-solution tank. The collecting tanks used as decanters were fitted with filter bottoms, consisting of boards perforated with 1-inch holes, covered with burlap, coco-matting, and light drill sheeting.

In usual practice the ore was crushed in cyanide solution averaging 0.05 per cent potassium cyanide. Cyanide was added in the collector to bring the strength of solution up to 0.15 per cent potassium cyanide. To neutralize the varying acidity of the quartz-calcite-ore from 5 to 20 pounds of lime per ton of ore were required. The capacity of the mill was from 60 to 70 tons per twenty-four hours with the stamps dropping at the rate of 100 per minute. Running at this capacity on average ore with the stamps crushing through 12-mesh and the tube-mill reducing the pulp until 95 per cent of it passed 100-mesh, the treatment recovered 90 per cent of the gold values. Power is supplied by a 6-foot Pelton wheel with a 100-foot head of water, supplemented by 2 gasoline engines of 15 and 25 horsepower respectively. Water for power is obtained by means of a diversion weir across the river about 500 meters above the mill and an 18-inch steel pipe line with a pressure box at the mill-site.

In March, 1912, the Headwaters Mine resumed operation under the management of Mr. Phillipson, of Baguio, with Mr. W. D. Power supervising the mill and the mine. Through the courtesy of these gentlemen the following data were obtained concerning the first cleanup.

Tons of ore treated	400
Hours of mill operation	178
Per cent of extraction (approximately)	90
Value of cleanup:	Pesos.
Gold	6,551.58
Silver	87.52
Total	6,639.10

Mr. Power made no attempt to use the Ridgway filter because of its extreme complication. Satisfactory results were obtained by decantation since the slimes settle rapidly. The ore for this run was considered to be representative of the average Headwaters ore in gold value. The mill is handicapped by insufficient power on account of the low stage of the river. It is planned to replace the gasoline engines by one of 50 horsepower. The present management is storing a quantity of supplies sufficient to permit the operation of the mine throughout the approaching

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wet season, in anticipation of the interruption of communication with Manila by floods.

The Bua Mine in the Antamok Valley, and the Muyot Mine and the Kelley Mine both in the Gold Creek Valley, are all properties on which extensive development work has been done. On the Bua, a Hendy 6-stamp mill has stood idle since October, 1909, when floods destroyed the flume which carried water for power and damaged the mill considerably.

Neither the Muyot nor the Kelley properties have installed mills. The Kelley Mine has opened up 5 separate veins which are partially developed by drifts and crosscuts. The ore is a pyrite-bearing quartz, and gold as a telluride has been reported. The veins are not all parallel and the resulting intersections and branchings suggest an irregular vein system or fracture zone.

On a number of other claims in the district, the annual assessment work has been done as usual. From the Bonanza group, east of the Headwaters Mine, ore containing visible free gold was encountered in recent development work.

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CANSURAN MINING DISTRICT.

By F. T. EDDINGFIELD.

LOCATION.

The Cansuran Mining district is located about 10 kilometers south of Surigao, Mindanao, near the center of the Peninsula of Surigao. The district extends from a little beyond Mounts Canmajat and Binutong north-easterly to the Surigao River, comprising principally the area between the Biga and the Tungunaan Rivers which flow into the Surigao.

HISTORY AND DEVELOPMENT.

It is said that over thirty years ago an Englishman operated in the district for a short time. About the year 1885 a Spaniard, Ricardo Gonzales, obtained a concession by which he controlled all the water rights of the district. He did no mining himself, but granted water rights to the natives for 25 per cent of the gold produced, with the privilege of buying at a very low figure all of the gold which they obtained. Since that time the natives have worked whenever sufficient water could be obtained for sluicing.

While the methods employed by the natives were very crude, they were able to recover a large percentage of the gold from the gravels. They carried water, sometimes several hundred meters by means of flumes made from the bark of trees, the most durable flumes being made of *palma brava*. Even a very small stream of water enabled them to do very extensive work. The water was led to the top of the face of the gravel to be worked and allowed to flow down it. The gravel was loosened by bars or shovels and was washed down through a narrow trench, which in places had to be cut through the bed rock. The light material was allowed to wash away, but the gravel, which accumulated in the trench, was raked and picked by hand and finally thrown up on one bank with coconut shells. The boulders were piled on one side of the trench, forming a wall which retained

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the waste. Boulders too large to be moved by hand were drawn out or to one side by means of a rattan rope which wound upon a post set vertically, guyed firmly with rattan, and fitted with one or two horizontal arms. Boulders too large to be moved in this maner were left in place and worked around. At regular intervals the concentrates in the bottom of the trench were panned to recover the gold. Some native workings are shown in Plate II.

In places where water could not be obtained, tunnels were driven along the bed rock and the rich gravels were carried down to water and panned. Some of these workings are very extensive, undermining large areas.

The cuts made by the natives give an excellent idea of the extent of the workable ground and of its value. The average miner can earn over a peso a day, when only two or three work together. When a large number work together, even better earning is reported.

TOPOGRAPHY.

The country between Surigao and the point where the Causuran Creek enters the Biga is a wide cultivated valley. A road is in use for 4 or 5 kilometers south of Surigao and is at present being extended; beyond this point, a trail, at places difficult for a horse, leads to the gold district. The Surigao River is too shallow in many places to permit the easy passage of large *bancas* beyond the point to which the road has been built.

The country between the Biga and the Tugunaan is very precipitous and hilly. The rivers and streams have cut deep channels through the country leaving steep slopes. The central portion northeast of Longong is comparatively flat, forming a plateau which slopes gradually toward the Surigao River. Southwest and west of Longong, however, prominent hills with steep sides make up the country. Taking the junction of the Biga and the Cansuran Rivers as zero, the elevation of Canmajat would be about 400 meters, Tabasingan 300 meters, and Binutong 250 meters. All the area is heavily wooded with tall trees which would have but little value as lumber, but which must be removed in order to work the ground.

CHARACTER OF THE DEPOSIT.

The gold occurs as placer and is unusually coarse for the Philippine Islands; many nuggets have been found weighing over 30 grams each. The great majority of the gold as brought in by the native workmen would not pass a 30-mesh screen and a large amount would be caught on a 10-mesh screen. The grains

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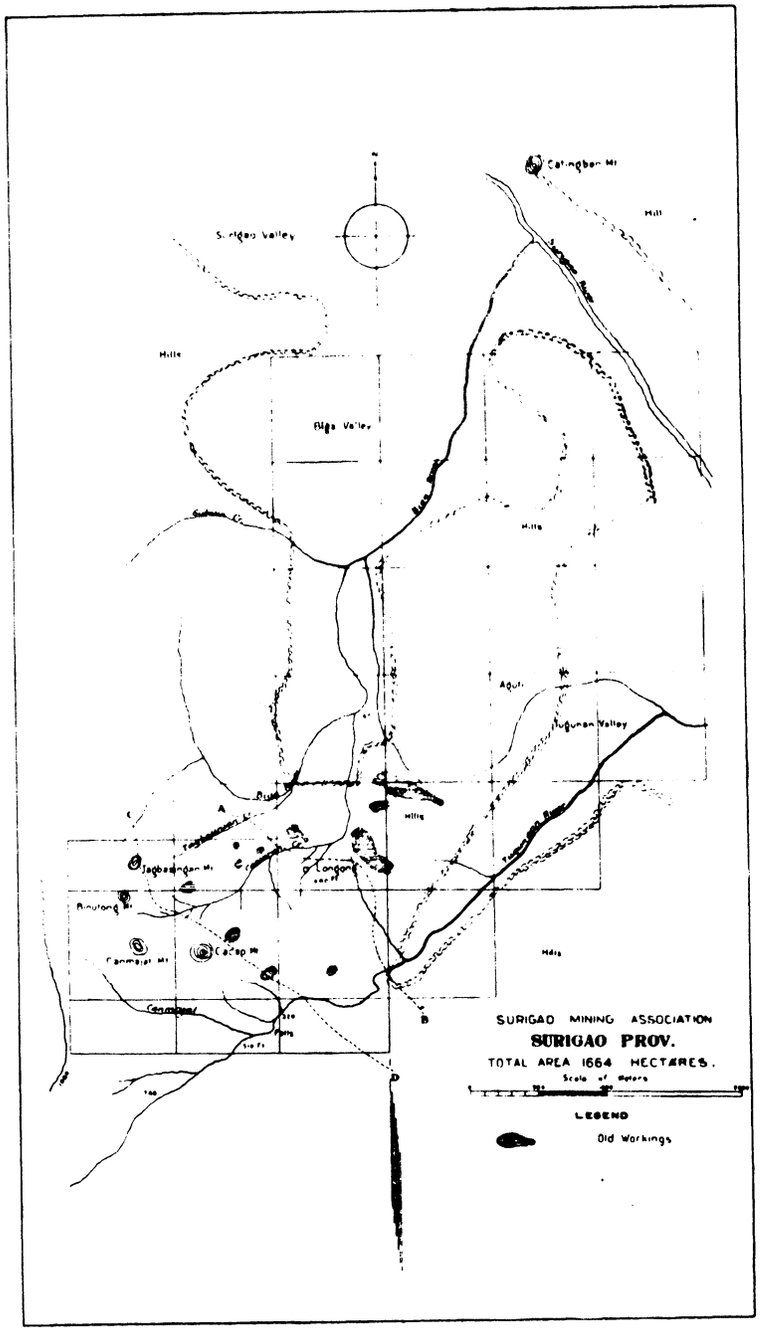

PLATE IV. MAP OF CANSURAN DISTRICT.

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are for the most part well rounded showing considerable movement, except on Tagbasingan and Canmajat Mountains where crystallized gold, often wire gold, is found which apparently has not been moved far. The workings on Canmajat are said to be in quartz and the gold to be panned from crushed rock taken from a vein which cuts across Canmajat, striking almost north and south. The average gold in the district runs about 790 fine in gold and 200 in silver.

The gold in the southwestern part of the property, that portion which is made up of high hills and ridges, is found in gravel beds from 3 to 10 meters thick. These beds cover the hills and ridges almost uniformly and have the appearance of being deposited by one or more old rivers. They are made up of coarse and fine gravels. Boulders weighing several tons are common, and boulders weighing from 10 to 100 kilograms each are very abundant. Most of these, probably 90 per cent, are andesite, others are schist, diorite, and red felsite. In the northwestern part along the Cansuran River some quartz pebbles were found, but the greatest part of the deposit contained no quartz pebbles of any size.

These gravel beds must have been the deposits from old rivers which washed the gold of the quartz veins and stringers from the formation which at that time covered the present surface. This old formation with its gold bearing veins and stringers has been mostly eroded and the present hills once formed the valleys in which the alluvium was deposited. The unusual distribution of the alluvium, covering the hill sides as well as their crests and also covering the depressions between hills, would tend to indicate that an uplift had taken place irregularly throughout the district and that the old river beds had been raised above their former positions. The character of the bed rock affords no conclusive evidence supporting this theory, although the northeastern part has undergone great compression stresses producing schists and much-folded shales. This was done previous to the deposition of the alluvium and consequently did not affect it.

The bed rock to the northeast of the line AB on Plate III is shale, much flexed and folded, having no uniform dip or strike. Between AB and CD a serpentine schist outcrops and forms the bed rock. This schist is much altered and decomposed and is so soft at the surface that 10 to 20 centimeters of the schist next to the alluvium contain high gold values. Coarse pegmatitic crystallization in spots is characteristic of this schist. To the west of the schist is found the andesite bed-rock not unlike the

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andesite boulders found in the alluvium. The highest peaks, Canmajat and Tagbasingan, show this andesite in place. Both of the peaks are said to contain quartz veins rich in gold. It is not improbable that the intrusion of this andesite produced the schists and compressed the shales.

The uplift of the district must have been more or less general over the entire peninsula, raising at the same time the limestones of the northwestern and eastern coasts. During the period following the uplift the erosion must have been very gradual as shown by the fact that a large part of the alluvium is in place. The heavy forests, which now cover the district must have sprung up during this period and subsequently served to hold the loose gravel in place. About a meter or more of soil covers the gravels proper. This soil was produced by the decomposition of the gravels as attested by the fact that it carries gold even within a few centimeters of the surface. The gravels below are somewhat weathered and partially cemented in places and contain gold values throughout, although the richest portions are found in certain beds and streaks which generally, although not universally, lie next to the bed rock.

VALUE OF THE DEPOSIT.

The present owners of the property have built a flume which carries water from a branch of Cansuran Creek to a reservoir situated about 50 to 60 meters above their present workings. From this reservoir water was obtained for operating a sluice and it is reported that the ground worked at this point averaged about 5 pesos per cubic meter. This was said to be an exceptionally rich area. On any piece of ground where water can be obtained the natives are able to make over a peso per day. Plate III shows the location of some of the native workings. Goodman, in his report,[1] stated that the average value of the ground worked in certain parts of this property was 2.08 pesos per cubic meter. He obtained this figure by measuring four days' work of a native miner with 3 assistants. This amounted to a recovery of 15.60 pesos worth of gold from 7.5 cubic meters of gravel. He stated further that this represented an average run for native miners in the district. Several test holes have been sunk by the present company over a considerable area from which pannings were taken and values per cubic meter estimated.

The water supply used at present by the Surigao Gold Mining Company is too small to furnish power for hydraulic operations.

[1] *Min. Resources P. I. for 1908, Bur. Sci., Div. Min.* (1909), 44.

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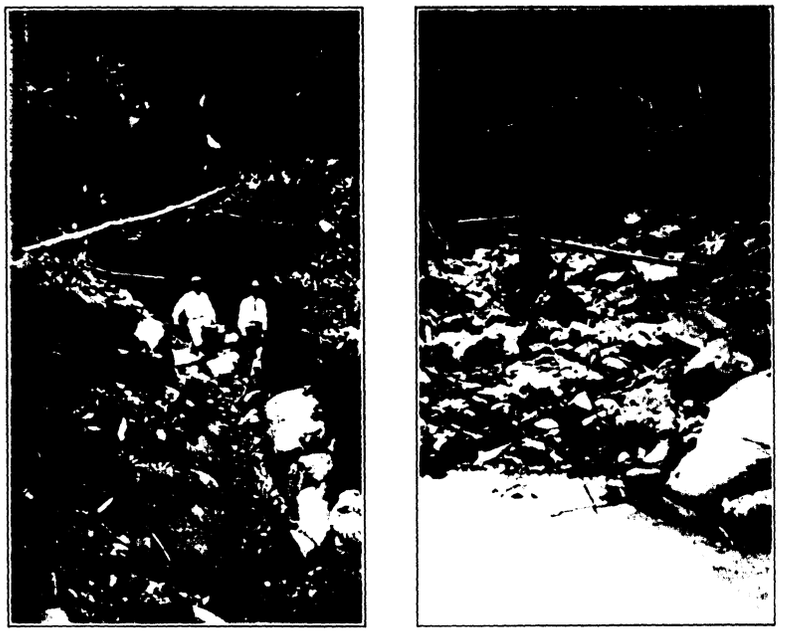

PLATE V. NATIVE WORKINGS, CANSURAN.

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A survey has recently been made locating a ditch from the Tugunaan River. It was found that this ditch could be built with little difficulty from the Tugunaan to their present reservoir, a distance of 1,700 meters, furnishing abundant water for several hydraulic machines. This would insure the working of all the gravels below an elevation of 120 meters, assuming the junction of the Biga with the Cansuran as zero elevation. There remains a large amount of ground above this elevation which could only be worked by means of a high pressure pump; this area is approximately equal to 3 full-sized claims, while the workable ground below the 120-meter mark amounts to about 6 full-sized claims.

If on account of probable unworkable and barren areas we assume 50 centavos as an average value of the ground, ignoring the values of 2.08 and 5 pesos calculated by other investigators and the value of 1 peso which was obtained in this investigation by estimating the value of numerous panning tests taken from working places throughout the deposit, the amount of gold recoverable by gravity water-power would be about 7,000,000 pesos (3,500,000 dollars U. S. currency) and an additional amount recoverable by high pressure pump 2,600,000 pesos (1,300,000 dollars U. S. currency).

The ground held by the Surigao Gold Mining Company consists of 22 full-sized claims and 8 half-sized claims, an area equal to 1,664 hectares (about 4,160 acres). A large part of the ground in this area not mentioned above as sluicing ground would probably prove to be good dredging ground, especially that portion lying in the Tugunaan Valley. This area contains about 600 hectares (1,480 acres). A few test holes have been sunk in this ground with a 3.5-inch drill, but no reliable results were obtained. One or two holes were sunk about 20 meters before bed rock was encountered.

CONCLUSIONS.

This property presents as great possibilities as any mining property in the Philippine Islands. That it has remained so long undeveloped is remarkable, but this is probably due partly to its distance from Manila, the unsettled condition of Mindanao, and the erroneous belief that it had been thoroughly worked over in the past.

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MISCELLANEOUS MINERAL DISTRICTS.

By F. T. EDDINGFIELD.

During the last year the center of mining activity has shifted from the north to the south. Very little has been reported from Mancayan, Suyoc, Ilocos Norte, Benguet, or Pangasinan. The only northern district attracting much attention has been northern Tayabas at Dingalan Bay, where rich deposits of placer gold were found. A dredge is now being built to work part of this ground.

The chief southern districts are Aroroy, Paracale, Marinduque, Milagros, Mindoro, and Mindanao. The first two are discussed elsewhere in this publication.

In Marinduque the stamp mill, erected 19 kilometers south of Santa Cruz, is standing idle because the ore at that point proved too irregular to be profitably worked. A large deposit of lead-zinc ore which may prove economical is reported about 10 kilometers from this point. It is said that transportation will probably be the only serious problem to be overcome.

At Milagros, Masbate, are copper deposits which have been prospected for several years under the direction of Mr. Brobst. A company has been formed called the Oklahoma Mining Company which did some development during the past year. Mr. Brobst reported that a 100-meter tunnel cut a vein 13 meters wide at a distance of 40 meters from the mouth, but the tunnel was continued to reach another vein supposed to be 80 meters farther. The vein cut contained lead and zinc.

A shipment of 10 tons of copper ore was sent to the United States from which the following returns were reported:

	Pesos.
Gold	200.00
Silver	85.00
Copper	600.00
Lead	20.00
Total in 10 tons of ore	905.00

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Mindoro is known to contain paying deposits of placer gold and several veins of copper. The presence of oil and gas has also been noted, but conditions have been unfavorable to their development.

Mindanao is attracting a great deal of attention. Placer deposits are found at Cansuran and Placer in Surigao, at several points in Misamis, and at numerous places in Butuan on branches of the Agusan River.

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BLACK SANDS OF PARACALE.

By P. R. FANNING AND F. T. EDDINGFIELD.

The division of mines, Bureau of Science, has been carrying on experiments to determine the economic possibilities of black sand and especially the black-sand concentrates caught on the tables of a dredge. A brief outline of the results obtained with the Paracale black-sand concentrates is given in the following article.[1]

The Paracale black sands are made up of the heavy minerals from the rocks and veins in the formation formerly surrounding the placer deposit. These rocks and veins were decomposed and eroded and the heavy particles were concentrated in the alluvials of the Paracale River.

BLACK-SAND CONCENTRATES.

Black-sand concentrates are caught on the tables of the dredge and contain the following minerals: magnetite, ilmenite, pyrite, zircon, limonite, pyroxene, olivine, quartz, gold, copper, metallic iron (partly from the dredge), and galena.

The gold occurs: (1) As nuggets, usually sharp and crystaline, free from other minerals, (2) as crystals bound up with quartz, (3) as crystals with magnetite, (4) as very fine gold free in the sand, (5) as very fine gold in quartz grains, (6) as very fine gold bound up in pyrite.

The dredge treatment of these concentrates recovers the majority of the nuggets and the coarse gold bound up with quartz, but only a small percentage of the very fine gold and practically none of the fine gold included in quartz and pyrite.

It was to ascertain the amount of gold lost and the best method of treatment that these experiments were carried on. A preliminary concentration test was made by panning-table concentrates crushed to pass 40-mesh. The concentrates obtained from panning were separated into magnetic and nonmagnetic products. The gold panned out was assayed separately.

[1] The complete discussion of this subject is to appear in the *Philippine Journal of Science.*

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Panning, magnetic separation test of table concentrates.[a]

[Values in Philippine currency.]

	Weight.	Composition.[b]			Assay.	Value distributed in 1 ton of original.
		Pyrite.	Iron.	Nonmetallic.		
	Grams.	*Per cent.*	*Per cent.*	*Per cent.*	*Pesos.*	*Pesos.*
Tails	10.76	20	10	70	16.82	1.80
Nonmagnetic concentrates	33.40	50	40	10	128.36	42.88
Magnetic	52.41	3	97	.....	2.40	1.26
Gold	.....	.....	.....	.....	.....	63.40
Loss in slime	3.43	.....	.....	.....	.....	101.92

[a] Original sample assayed 211.26 pesos. [b] Estimated by the eye.

A second sample of 200 grams treated in the same manner with extreme care gave:

[Values in Philippine currency.]

	Weight.	Assay.	Value distributed in 1 ton of original.
	Grams.	*Pesos.*	*Pesos.*
Nonmagnetic	91.4	102.80	51.00
Magnetic iron	107.5	13.20	7.08
Gold	.....	.....	91.78
Loss	1.1	.....	61.40

Some of the free gold is coated with iron rust and consequently is difficult to amalgamate; the crushing also liberated more free gold than an original sample would contain; this is shown in the following amalgamation test on the original sample.

Amalgamation test on original table concentrates.

[Values in Philippine currency.]

Weight of sample.	Assayed original.	Tails.	Gold recovered.	Gold recovered.
Grams.	*Pesos.*	*Pesos.*	*Pesos.*	*Per cent.*
1,033.4	211.26	127.26	84.00	39.7

The amount recovered by panning the crushed sample was 43.4 per cent and the amount recovered by amalgamation of the original 39.7 per cent. It can not be expected that the dredge could save more than either of these tests and it is probable that it can not save nearly as much.

This sample was supposed to be a representative sample from the dredge, and if this were the case it is apparent that the dredge loses more than 50 per cent of the gold in the ground. This figure has been confirmed by sampling the dredge tailings, concentrating and assaying them, and estimating the total amount of this class of sand wasted and comparing the result with the output of the dredge.

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This does not mean that the dredge loses 50 per cent of the value of the ground as estimated by drive-pipe tests, for such is probably not the case. The drive-pipe tests themselves show only 50 per cent or less of the gold actually in the ground for such tests and are analogous to the panning concentration tests given above, where less than 50 per cent of the gold content is saved as free gold.

METHODS OF TREATMENT OF TABLE CONCENTRATES.

Sample No. 1 represents the black sand caught in the tables and riffles of the dredge, and thrown aside after panning out the free gold in the regular cleanup. Sample No. 2 represents the concentrates in which mercury had been used by the dredge during its cleanup. The following tests were made:

Magnetic separation.—The majority of the gold in the sample occurs free (due to improper panning in the dredge cleanup) or in association with the nonmagnetic material. Hence magnetic treatment will remove a great bulk of low grade tailings and leave a high grade shipping product. This is shown in the following test:

Magnetic separation test on sample No. 2.

[Values in Philippine currency.]

Products.	Weight.	Weight.	Value per ton.	Gold.
	Grams.	*Per cent.*	*Pesos.*	*Per cent.*
Original	3,595	100	100.00	100
Nonmagnetic	2,100	58.3	170.40	97.21
Magnetic	1,495	41.7	7.50	2.79

As indicated by this test, 100 tons of concentrates worth 112 pesos per ton can be separated to give 58.3 tons worth 170.40 pesos per ton and containing 97.21 per cent of the gold.

Conclusion.—A rich shipping product is easily obtained by magnetic separation of the original product.

Amalgamation tests.—Amalgamation was tried with the original and also after grinding the original through various meshes. A few of the tests are given in the following table:

Amalgamation tests on sample No. 1.

[Values in Philippine currency.]

Products.	Heads, value per ton.	Tails, value per ton.	Gold saved, per ton.	Gold saved.
	Pesos.	*Pesos.*	*Pesos.*	*Per cent.*
Original	211.26	76.80	84.00	39.7
Original put through 60-mesh	211.26	67.36	143.90	68.0
Original put through 80-mesh	194.20	49.60	[a] 174.60	74.4
Original tube-milled, 79 per cent through 100-mesh	169.82	15.22	[a] 154.62	91.0

[a] Variations in sampling or else actual loss of gold by grinding.

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The tests were made by revolving the ore in a bottle with mercury and a little sodium hydroxide, for one hour. The mercury was panned out and dissolved in nitric acid and the gold cupelled to give check on the assay of the tailings. It is very unlikely that any machine or system of plates will give an equivalent extraction on the finer meshes.

Conclusions.—Only 39.7 per cent of the gold in the original can be amalgamated. Grinding releases more and more gold until with very fine grinding 91.0 per cent of the amalgamable gold is released. Tube-milling, followed by plates, will probably give much less than 91.0 per cent extraction.

Cyanidation tests.—Cyanidation tests were made on the original, at various meshes and in combination with amalgamation. Important results were obtained.

Cyanidation tests on sample No. 1.

Test No.	Product.	Extraction by amalgamation.	Extraction by cyanidation.	Total extraction.
				Per cent.
1	Original	39.7 per cent	Product not cyanided	
2	Original	Product not amalgamated.	25 per cent in 24 hours	
3	Original put through 60-mesh	21.10 per cent	57 per cent in 48 hours 82.3 per cent in 96 hours	73.5 89.0
4	Original put through 100-mesh	23.16 per cent	92 per cent in 48 hours 93.7 per cent in 96 hours	96.0 96.5
5	Original tube-milled 98 per cent through 150-mesh.	59.7 per cent	97 per cent in 48 hours 91.1 per cent in 96 hours	99.0 99.1
6	Original tube-milled 98 per cent through 150-mesh.	Product not amalgamated.	80 per cent in 24 hours 98 per cent in 96 hours	

The strength of the solution was 0.29 per cent potassium cyanide; the pulp ratio was 3:1; the consumption averaged 5 pounds per ton of ore; lime was added and agitation employed in all cases. Tests 3, 4, and 5 were first pulverized,[2] then amalgamated, and the tails cyanided. Test No. 6 was tube-milled and cyanided direct.

Conclusions.—Fine grinding, agitation, and considerable time are necessary, and will give an extremely high extraction. When the coarse gold can not be powdered by the tube-milling, amalgamation may be necessary.

COMMERCIAL CONCLUSIONS.

The amount of table concentrates at present saved is too small to warrant the installation of an expensive plant for either amalgamation or cyanidation.

The following table shows the relative advantages of shipping concentrates with and without magnetic separation and of local treatment in Huntington mills.

[2] A report on the screen tests will be published in the *Philippine Journal of Science.*

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Comparison of shipment of concentrates and treatment in Huntington mill.

[Values in Philippine currency.]

Items.	Magnetic separation and shipment.	Shipment of original per ton.	Huntington mill.
		Pesos.	*Pesos.*
Value of original	One ton worth 200 pesos separates to 0.58 ton worth 194.42 pesos.	200	200
Cost of treatment	16 pesos for 0.58 ton	30	2
Extraction	185.00 pesos	190	140
Profit	169.00 pesos	160	138

The greatest profit is to be obtained by magnetic separation and shipment of the product. The least profit is to be obtained by treatment in the Huntington mill. The comparison between magnetic treatment and direct shipment is quite close. Therefore, for the present it would be more advisable to ship direct without magnetic treatment. More tests should be made to determine the efficiency of magnetic treatment and the feasibility of installing machines.

FUTURE POSSIBILITIES.

The question of how to save the black sands is not within the scope of this paper. It has been shown, however, that after the sands are saved, they can be successfully treated by several methods.

The amount of black sand in the gravel is very large and even rough concentration should give for a dredge some 10 tons per day worth over 30 pesos per ton. Experiments should be made with the Richards pulsator jig and other machines to see if a concentrated product can be obtained cheaply. It might be possible to obtain a considerable amount of concentrates by means of a more extended series of riffles and more frequent cleanups.

With several dredges in operation sufficient concentrates should be obtained to warrant the erection of a central cyanide plant. It would seem that tube-milling in cyanide solution followed by air-agitation, decantation, and the usual precipitation would give an especially high extraction at nominal cost.

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THE IRON INDUSTRY IN 1911.

By F. A. DALBURG.

The iron industry in the Philippine Islands in 1911 shows a slight increase over the production for 1910 but the output has not been brought up to the total for 1909. The total value of iron produced in 1911 was 29,159 pesos. This figure represents the value of plowshares and points cast directly from the furnace by ladling the molten iron out of the hearth. There are no statistics available to show the quantity of iron ore mined. An estimate based on a recent test of one furnace in the Angat iron district is given in Table I and shows approximately in metric tons the quantity of iron ore mined and metallic iron produced from 1908 to 1911 inclusive.

TABLE I.—*Production of iron ore, and iron castings 1908–1911, metric tons.*

Years.	Iron ore mined.	Iron castings produced.
1908	289.5	96.5
1909	234.0	78.0
1910	150.0	50.0
1911	219.0	73.0

Although rich deposits of iron ore occur in several provinces throughout the Philippines, the development of these resources has been limited to the Angat district in Bulacan Province. During the year 1911, 5 operators have worked a total of 12 furnaces at irregular intervals. New bodies of ore have been discovered at Macatalinga, Mayapa, Tagpis, and Tumotulo and furnaces erected near them. A furnace has again been put into blast in the old Camachin district.

A complete description of the native process of smelting iron has been given by McCaskey,[1] but a brief résumé will be given here for readers who may not have access to the report mentioned.

The native furnace is constructed from clay, and consists of a cylindrical stack 2.25 meters in height and 1.35 meters in

[1] *Bull. P. I. Bur. Min.* (1903), 3.

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diameter pierced by one tap opening in front for slag and iron and one tuyere opening at the back. Cold blast is delivered through baked clay tuyeres by means of a blowing apparatus consisting of a hollow log 35 centimeters in diameter and 3.50 meters long. A wooden piston with a feather lining is fitted into the log and attached to a wooden piston rod. The blower is double acting with valves at each end and is worked by hand. The length of stroke is 1.90 meters and the number of strokes varies from 16 to 20 per minute. The thickness of the hearth wall is 45 centimeters and the crucible formed by the walls is shaped like an inverted bell, 60 centimeters in diameter at the bottom and 1 meter in diameter at the top, with a height of 1.75 meters. The crucible terminates at the bottom in a rectangular runner, 13 centimeters wide and 12 centimeters high extending from the tap hole in front to the tuyere opening at the back of the furnace. It is lined with a mixture of charcoal and clay, and serves for collecting the melted iron and slag.

Charcoal fuel is used and is charged into the furnace from baskets. The ore is rich hematite and magnetite. In smelting, the charge which is made about every two hours was found to average 25 kilograms of ore with 37.5 kilograms of charcoal. The ore and fuel are evenly distributed over the top of the furnace. The top of the furnace and the tap hole are left open and the flame constantly emitted at these places varies with each stroke of the blower. No flux is added to the charge but the clay tuyeres are eaten away rapidly and furnish silica to the slag. It requires about two hours for the iron to run down. Slag is tapped every hour and iron about every three hours. The smelting lasts from twelve to fifteen days, when it becomes necessary to stop the operation, clean the furnace of slag, and reline the bottom.

The plowshares and points are made direct from the furnace by ladling out the molten iron and pouring it into clay molds.

One operator is constructing a 76-centimeter foundry cupola of 5 tons capacity. This installation marks an important advance over the present clay furnaces in smelting practice. The results from this furnace will be awaited with interest.

The most active operations have been carried on at the Hizon and Montamuro mines and the greater percentage of iron produced has come from these properties.

No active work has been done in the Paracale-Mabulao district, in Ambos Camarines Province, although preliminary investigations have been made in regard to shipment of ore from Calumbayanga Island.

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The division of mines has just completed an examination of the Angat iron region covering an area of nearly 100 square kilometers. Surveys with compass and dip needle have been made, ore-pits measured, and an attempt made to estimate the ore tonnage in the area mapped.[2]

The total imports of iron and steel goods for the years 1908 to 1911 inclusive as compiled from the Annual Reports of the Bureau of Customs, are given in Table II, showing imports subject to duty, and Table III, showing imports free of duty. In many cases the quantities and values are not given, but a minimum estimate can be obtained from the figures shown.

TABLE II.—*Imports of iron and steel goods subject to duty.*

[Quantities stated in metric tons. Value given in Philippine currency.]

Articles.	Twelve months ending June—							
	1908		1909		1910		1911	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*
Pig iron	1,288	52,972	222	21,762	1,234	39,876	1,326	53,076
Bar iron	2,021	148,906	2,148	152,892	2,249	126,570	2,992	185,146
Bars and rods of steel	1,767	146,834	1,990	153,684	4,208	319,694	9,562	558,532
Rails (iron)	285	24,552	431	44,508	438	31,566	.....	.....
Rails (steel)	2,208	139,654	404	25,250	11,783	687,706	5,093	363,812
Steels and plates (iron)	4,573	632,220	5,541	711,724	8,348	1,069,318	11,183	1,560,752
Steels and plates (steel)	666	55,896	1,125	98,078	1,221	109,740	1,483	108,504
Structural iron and steel	722	108,094	1,154	139,480	588	51,052	4,128	438,268
Iron, scrap and old	104	3,256	.....	.....	.....	.....	.....	.....
All other manufactures	.....	3,015,030	.....	2,518,646	.....	4,176,868	.....	8,506,364
SUMMARY.								
Source:								
United States	.....	1,604,626	.....	1,637,096	.....	3,940,980	.....	7,819,122
All other countries	.....	2,725,188	.....	2,228,968	.....	2,670,410	.....	3,955,332
Total	.....	4,329,814	.....	3,866,064	.....	6,611,390	.....	11,774,454

TABLE III.—*Imports of iron and steel goods free of duty.*

[Quantities stated in metric tons. Value given in Philippine currency.]

Articles.	Twelve months ending June—							
	1908		1909		1910		1911	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
PHILIPPINE RAILROADS.	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*
Iron and steel in sheets	326	31,480	745	9,612	50	6,182	21	2,372
Structural iron and steel	7,785	953,304	4,562	481,522	1,000	123,516	401	39,112
Rails	11,616	827,460	4,754	337,384	86	6,208	.....	.....
All other manufactures	.....	451,932	.....	384,232	.....	357,784	.....	149,842
U. S. ARMY, NAVY, AND INSULAR GOVERNMENT.								
Iron and steel	6,454	.....	6,424	.....	5,223	.....	.....	1,974,604

[2] The results of this examination will be published at an early date in the *Philippine Journal of Science.*

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MANGANESE DEPOSITS OF THE PHILIPPINE ISLANDS.

By PAUL R. FANNING.

The rapidly increasing demand for manganese has caused attention to be turned to the deposits in the Philippine Islands. Manganese and manganiferous ores have been found in many parts of the Islands, but practically no ore has been produced to date. This is due in part to the high cost of transportation and in part to the limited amount of ore in sight.

The Philippine deposits, similar to occurrences elsewhere in the world, are largely secondary concentration deposits, and can conveniently be divided into manganese and manganiferous ore-deposits.

MANGANESE ORE DEPOSITS.

Manganese ore deposits occur in Ilocos Norte, Pangasinan, Bulacan, Sorsogon (Island of Masbate), and Tarlac Provinces.

Ilocos Norte.[1]—The Province of Ilocos Norte is situated in the northwestern corner of Luzon, and the manganese ore is found in the Nagpartian hills, especially between Punta Negra and Punta Blanca. The ore occurs as nodules and grains lying upon the surface of the ground especially along gullies where gravity and water have produced a natural concentration. The nodules and grains consist mainly of psilomelane which generally is massive, hard, grayish black, and structureless. The surfaces frequently are botryoidal. Pyrolusite is generally associated with the psilomelane and appears to be a secondary product. Veinlets of psilomelane and pyrolusite occur in the andesitic country-rock and the vein-filling has been released by weathering to the formation of the nodules and grains. Near Punta Negra a bed of concentrates occurs which is about one-half meter thick and is underlain by a thin layer of limonite. This in turn rests upon an andesitic agglomerate. The extent of the deposit is not known, but probably it is not sufficient to warrant any great original outlay of capital for development purposes.

[1] Cf. Smith, *Phil. Journ. Sci., Sec. A* (1907), 2, 145.

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Analysis of a nodule gave the following results:[2]

Analysis of manganese nodule from Ilocos Norte.

Constituent.	Per cent.
Silica (SiO_2)	1.10
Ferric oxide (Fe_2O_3)	4.04
Moisture (H_2O) at 110°	10.55
Phosphoric anhydride (P_2O_5)	0.02
Manganese dioxide MnO_2	77.51
Total	93.25
Metallic (Mn)	48.93

Pangasinan.—The Province of Pangasinan is situated about 100 kilometers north of Manila, and the manganese ore is found west of Sual, at the *sitio* of Barlo, in the northwestern part of the province. The ore, similar to the deposit in Ilocos Norte, occurs as nodules and grains lying upon the surface of the ground, and has resulted from the weathering of the country rock. Nodules up to 20 centimeters in length were seen. The secondary concentration into beds is very limited, and the deposit appears to be of little value. Analysis of the ore gave the following results:

Analysis of manganese nodule from Pangasinan.

Constituent.	Per cent.
Manganese (Mn)	58.58
Iron (Fe)	0.55
Phosphorus (P)	0.100
Aluminium (Al)	0.88

Bulacan.—The deposit in the Province of Bulacan lies about 50 kilometers northeast of Manila, at Minuya near the town of Norzagaray. As described by Nable[3] the ore occurs as nodules and grains of psilomelane and pyrolusite scattered over the surface of the ground, and, similar to the occurrences in Ilocos Norte and Pangasinan, has resulted from the weathering of the country rock and some subsequent secondary concentration by surface waters. Analysis of the nodules would undoubtedly show a high per cent of manganese, but the deposit appears to be so limited as to be of no commercial value.

Tarlac.[4]—The deposit in the Province of Tarlac lies about 50 kilometers northwest of Manila on the road between Capiz and Iba. The ore occurs as nodules in bedded deposits, and apparently is of residual nature and probably similar in origin to the deposits of Ilocos Norte, Pangasinan, and Bulacan.

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[2] *Ibid*, p. 171.

[3] Unpublished notes in division of mines, Bureau of Science.

[4] Harder, *Bull. U. S. Geol. Surv.* (1910), 427, 220.

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Masbate.[5]—The Island of Masbate lies about 200 kilometers southwest of Manila, and the ore is found in the Aroroy mining district in the northern part of the island. Manganese claims have been staked in the areas of red slates to the east of Balangting Creek and west of Mount Vil-lon, but practically no development work has been done. The manganese ore occurs as lens-shaped nodules within slate, parallel to the slaty cleavage. Between Kaal Creek and Mount Vil-lon there is a small plain at about 50 meters elevation where boulders of psilomelane are found on the surface. These boulders have evidently resulted from the weathering of the slate upon which they lie. In certain places the slate contains minute networks of quartz and calcite veinlets, and it is possible that the nodules in the slate have resulted from the leaching out of the manganese in the veinlets and secondary concentration along the cleavages in the slate. An analysis of a nodule gave the following result:[6]

Analysis of manganese nodule from Masbate.

Constituent.	Per cent.
Manganese (Mn)	59.77
Silica (SiO_2)	10.41
Phosphorus (P)	0.027
Sulphur (S)	0.037
Gold	trace
Silver (ounces)	44.0

The assay of 44 ounces of silver is quite extraordinary and further investigation should be made to confirm this point.

MANGANIFEROUS ORE DEPOSITS.

Manganese is found in association with gold ore veins, especially in Benguet and Masbate.

Benguet.—The Benguet mining district lies northeast of Manila about 150 kilometers, close to the City of Baguio. Manganese occurs abundantly in the auriferous calcite or calcite-quartz veins of the Camote-Clayton, Headwaters, Gomok, Eileen, Antamok, and Madison properties, and in the auriferous quartz (possibly some calcite) veins of the Emerald Creek and Madison properties. To some extent manganese is found in other mines. The marked association of manganese with calcite rather than quartz is to be noted, and the evidence points to a genetic relation.

In the primary ore the manganese appears to occur as oxides or as carbonates (manganiferous calcite, rarely rhodochrosite).

[5] Ferguson, *Phil. Journ. Sci., Sec. A* (1911), **6**, 404 and 422.
[6] Harder, *Bull. U. S. Geol. Surv.* (1910), **427**, 220.

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The manganese gives a brown color to the calcite, and alternations of white and brown calcite along with quartz often give a characteristic banded or ribbon structure. It is evident that the original ascending solutions which produced the vein periodically precipitated manganese, and it would seem to follow that these solutions were periodically high or low in manganese.

In the zone of oxidation, particularly that part of the zone close to the surface, the manganese is much more abundant than in the primary ore. In places, extended replacement of the calcite by manganese in the form of wad has taken place, giving bodies of ore rich in manganese. The percentage of manganese is very irregular and will vary from a trace to 50 per cent.

It is evident that the higher manganese content of the ores in the zone of oxidation is due to the secondary enrichment by descending waters. These waters leached manganese from the ore above and carried it downward along the vein until precipitating conditions were found. Such conditions in calcite veins were found quite close to the surface, where the greatest concentration of the manganese and replacement of the calcite occurs. This tendency to concentrate near the surface has been further accentuated by the natural accumulation of some of the manganese released by weathering.

The veins occur in a region of very rapid erosion and this has resulted in primary ore frequently outcropping on the surface. The great majority of the primary manganese in the ore is carried away by erosion before being leached or mechanically carried downward by the surface waters. There is then little opportunity for the formation of large bodies of high-grade manganese ore anywhere along the vein.

The soil on the outcrop of the vein shows no nodules nor grains, although frequently it is heavily stained with manganese. It would seem that in igneous rocks where manganese occurs in intimate association with the calcite vein-filling, the conditions are unfavorable to the formation of nodules or grains of psilomelane. The explanation of this is that massive psilomelane does not form under the conditions present, as the manganese is precipitated in the form of soft, earthy wad. Further, there has been little or no tendency of the manganiferous solutions to invade and replace the adjacent rock. This is due on the one hand to the vein being the more natural channel and to the easily replaced calcite of the vein; and on the other hand to the compactness of the igneous rock and its resistance to replacement. There has been no tendency of the manganese to spread out into

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the adjacent rocks to the formation of kidneys or nodules of psilomelane or pyrolusite.

The occurrences of manganese in association with true quartz veins is somewhat different from that in the calcite veins, although the general process of enrichment appears to be similar. The ribbon structures produced by bands alternately high and low in manganese content is infrequent, and the manganese visible to the eye appears to be entirely secondary. It is quite possible that the manganese occurs as a primary association with occasional crystals of calcite, and hence in obedience to the general association, for this district, of calcite and manganese rather than calcite and quartz.

As summarized by Emmons,[7] practically all of the manganiferous gold deposits of the United States particularly, in the Western States, belong to the Cretaceous or Tertiary age. The manganiferous gold deposits of the Philippine Islands likewise are of Tertiary age and so give one more bond of similarity between the geology of these Islands and the geology of the Western States, particularly California.

Owing to the impossibility of satisfactorily concentrating manganese out of these ores, and the high cost of shipping, it is doubtful if the vein deposits in Benguet can ever be considered as actual ore deposits of manganese.

Masbate.—In the Aroroy district, manganese is found associated with the calcite ores in the Eastern Mine and to a lesser extent with the quartz (some calcite) ore of the Colorado Mine. Some other mines are also known to contain manganese. The occurrences are quite similar to the Benguet deposits just described, but it seems that the zone of manganese enrichment is more developed in the case of Masbate. As pointed out by Ferguson,[8] the greater depth of oxidation in this district may be due to the former greater elevation of the region. As an additional explanation, it is to be noted that the erosion in Masbate is far slower than in Benguet, and so more opportunity has been given for the leaching out of the manganese and reprecipitation below.

PRICES OF ORES.[9]

The prices of manganese ores used in the steel industry vary from 10 pesos (5 dollars) to 30 pesos (15 dollars) per long ton, according to the grade of the ore. They are governed by the

[7] *Trans. Am. Inst. Min. Eng.* (1910), 814.
[8] *Phil. Journ. Sci., Sec. A* (1911), **6**, 417.
[9] Harder, *Bull. U. S. Geol. Surv.* (1910), **427**, 278.

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following schedule of prices established by the Carnegie Steel Company:[10]

Schedule of prices paid per ton of 2,240 pounds for domestic manganese ore delivered at Pittsburg or Bessemer, Pa., and South Chicago, Ill.

Prices are based on ores containing not more than 8 per cent silica or 0.20 per cent phosphorus, and are subject to deductions as follows: For each 1 per cent in excess of 8 per cent silica there shall be a deduction of 0.30 peso (15 cents U. S. currency) per ton; fractions in proportion.

For each 0.02 per cent, or fraction thereof, in excess of 0.20 per cent phosphorus there shall be a deduction of 0.04 peso (2 cents U. S. currency) per unit of manganese per ton.

Percentage of metallic manganese in ore.	Price per unit in cents.	
	Manganese.	Iron.
Over 49	26	5
46 to 49	25	5
43 to 46	24	5
40 to 43	23	5

Ores containing less than 40 per cent manganese or more than 12 per cent silica or 0.225 per cent phosphorus are subject to acceptance or refusal at the buyer's option.

Settlements are based on analysis of sample dried at 212° F., the percentage of moisture in the sample as taken being deducted from the weight.

The manganese ores for oxidizing and coloring purposes are valued according to the quality of manganese peroxide present, their consistency, etc., and prices range up to 70 pesos per ton for the best grades of ore. Manganiferous ores used in steel manufacture and for fluxing range in price from 4 pesos a ton upward.

[10] Prices of manganese ore. *Eng. and Min. Journ.* (1910), **89.**

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THE PRODUCTION OF NONMETALS IN 1911.

By WALLACE E. PRATT.

TABLE I.—*Production of nonmetals in 1911.*

Commodities.	Quantity in cubic meters.	Value.	Average unit value.
		Pesos.	*Pesos.*
Crushed stone	209,131	536,008	2.56
Rough and cut stone	100,396	119,787	1.19
Sand	252,624	79,367	0.31
Gravel	377,511	397,977	1.05
Clay products		450,000	
Lime		90,000	
Salt		550,000	
Coal		130,000	
Total		2,353,139	

The value of nonmetallic mineral products for the year 1911 was more than 36 per cent greater than the production for 1910. This gain is due largely to the increased quantities of structural materials and road metals used, although the nonmetallic products except coal all show increases for the past year.

STRUCTURAL MATERIALS AND ROAD METALS.

Concrete aggregates.—In the Philippine Islands first class construction is almost entirely of reënforced concrete. This condition results primarily from the efforts of engineers to build permanent structures in a region subjected to frequent earthquakes, although the lack of a perfectly satisfactory dimensional stone contributes in some degree to the prevalence of concrete. It is estimated that 90,000 cubic meters of sand, 190,000 cubic meters of gravel, and 25,000 cubic meters of crushed stone have been used in concrete work during the year 1911. These materials are obtained locally in all parts of the Islands, and vary greatly in costs; the average "spot" values[1] are given in Table I. River gravel is cheaper than crushed stone and is more widely used in concrete aggregates. The gravel from most localities consists of igneous pebbles among which andesitic types prevail;

[1] "Spot" values include no cost of transportation.

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gravel from limestone is rare. Quartz sand is scarce and little used, the most generally available sand consisting of rock fragments, feldspars, and other rock minerals eroded from igneous rocks of low quartz content. In the Mountain Province, away from the coast and where the rivers flow through narrow cañon-like valleys, sand is so difficult to obtain that it has been necessary at some places to use the fines from crushed rock as sand. In Baguio, pure silicious sinter which occurs abundantly as a fine white powder has been used with cement in place of sand.

Sand used in Manila is obtained principally from the Pasig River by dredging. As in past years, some sand has been taken from the Pasig River by native divers who bring it up in small baskets.

Road metals.—Crushed rock and gravel have been used very extensively in road building. Crushed rock is used both as a basal course and as road-surfacing material, while gravel is more generally used for surfacing. More than 100,000 cubic meters of crushed rock and about the same quantity of gravel were used in road construction in 1911.

One of the most satisfactory road metals in Philippine roads up to the present is a diorite occurring in Pangasinan Province. The diorite shows a satisfactorily low percentage of wear in the standard abrasion tests, and a remarkable cementing value. Tests made at the Bureau of Science have recorded values for this rock of more than 2,000. Smith has shown that the diorite contains secondary calcite to which he attributes the abnormal cementive property.

Andesite is the most widely used road metal, owing to its general distribution. The best andesite shows less than 2.0 per cent of wear in abrasion tests and a cementive value of about 20. Owing to its poor cementation, andesite is not wholly satisfactory for ordinary macadam road, but when used, as it has been on several of the recently paved streets of Manila, with a tar binder for the surface course, it makes a superior pavement which on account of the abrasion resisting qualities of the rock should be very enduring. Coralline limestone serves as a road metal in some provinces. It abrades readily, but presents a well-cemented surface and makes an excellent road.

More than 300,000 cubic meters of sand and gravel have been used as ballast on the lines of the local railway companies.

Natural cinder ballast.—The Manila Railroad has been using a natural cinder for ballast with very satisfactory results. This cinder is obtained from an extinct cinder cone at Pansol, Laguna, in the volcanic region of southwestern Luzon. It has

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the general appearance of ordinary cinder ballast but is slightly more reddish in color. It affords a clean dry road bed. Some 50,000 cubic meters have been taken out in 1911, and it is estimated that 150,000 to 250,000 cubic meters are yet available in this one cinder cone. The cinder is not consolidated, and quarrying is inexpensive.

Rough and cut stone.—In Manila and the outlying towns in the volcanic tuff area of southern Luzon, some tuff has been used for masonry. It is sold under the trade name of "adobe" and is used in the construction of foundations and the lower stories of many Chinese business buildings. Cut stone is used to a limited extent at points where transportation cost prohibits the importation of cement. Next to "adobe" stone, limestone is most generally employed, and lime kilns are usually operated in connection with the limestone quarries.

Rough stone for construction has been used principally as riprap and filling for sea wall, fortifications, and harbor improvements. In road building rough stone is made to serve as a basal course. In Manila and vicinity "adobe" stone, quarried in rough blocks, is used for this purpose and affords a base which is porous and drains well. About 37,000 cubic meters of "adobe" stone were used for road building in 1911.

Clay products.—It is estimated that approximately 4,000,000 common bricks valued at 20 pesos per thousand were manufactured by native methods during the past year. More than 50 per cent of this production come from the brick yards near Manila.

The native method of manufacture has been described elsewhere.[2] The Penal Colony of Iwahig, Palawan, has recently installed a modern, stiff-mud brick machine with a daily capacity of 25,000 bricks. Brick will be made for construction within the colony, and if the industry progresses successfully brick will ultimately be supplied to other departments of the Government.

The larger part of the production of clay ware consists of crude native pottery including large semivitrified jars for containing water and other liquids, small water jars and cooking pots, etc., articles which are manufactured locally in every part of the Islands.

Lime.—Lime is used for mortar in much of the native construction in Manila and in all masonry work at places where cement

[1] Production of Nonmetallic Materials in 1910. Pratt, *Min. Resources P. I. for 1910, Bur. Sci., Div. Min.* (1911), 62.

Philippine Pottery. Adams and Pratt, *Phil. Journ. Sci., Sec. A* (1910), 5, 143.

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can not be obtained economically. Outside of the use in construction lime serves as a disinfectant, and the modern sugar mills which are being erected probably will use lime in bleaching sugar. Lime is burned in Manila from sea shells, and throughout the provinces from coralline limestone. Lime on the Manila market, where it is sold in a semislacked condition, brings from 3 to 4 pesos per hundred kilograms.

Cement.—No cement has been manufactured in the Philippine Islands, up to the present time. There has been an extensive investigation of cement resources during the past year by capital contemplating the establishment of a local industry. Chemically suitable materials from some of the localities considered to be most favorable have been burned and the resulting cement submitted to the standard tests. These tests show that from raw materials commercially available a high grade Portland cement can be manufactured. Philippine consumption (see page 83) is equal to the output of a fair-sized mill and is increasing steadily. Apparently, the conditions justify the erection of a cement mill for commercial manufacture.

COAL.

The East Batan Coal Mining Company has passed through a reorganization period during the past year and the annual production has suffered accordingly. The only other property which was operated in 1911 is the Camansi Mine at Danao, Cebu. The United States Army Mine at Liguan, Batan Island, has been kept open and dry but no coal save that for use at the mine had been taken out.

MISCELLANEOUS NONMETALS.

Oil.—The oil-seeps in Tayabas, Mindoro, and Cebu and the reported occurrence of oil in Pangasinan have all received more or less attention during the past year, but in none of the districts has development progressed far enough to prove the oil present in economically important quantities.

Salt.—The value of the salt manufactured during the past year is estimated at 550,000 pesos. The cost of salt varies widely at different places. In Manila the coarse native product ranges from 2 to 2.50 pesos per hundred kilograms, while in provincial towns away from the coast, it is often sold at a price equivalent to 8 or 10 pesos per hundred kilograms.

Guano.—No production of guano is recorded, although insignificant quantities of bat guano are recovered from limestone caves at a number of places throughout the Archipelago. In

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the caves the guano occurs as a superficial layer, usually less than 1 meter deep, over the floor. It consists of the excrement of bats which inhabit the caves. From the caves near Sibul Springs, Bulacan, guano is sent to neighboring towns and even into the adjacent Province of Nueva Ecija. Some guano has been taken from caves on the Island of Panay and sent to the Manila market.

The quality of bat guano for fertilizer can be estimated from the following partial analyses made in this Bureau of samples from different places in the Islands.

TABLE II.—*Analyses of undried samples of guano.*

Source of sample.	Total phosphorus pentoxide (P_2O_5).	Total nitrogen (N_2).	Available potash (K_2O).
	Per ct.	*Per ct.*	*Per ct.*
Limestone cave near Dingle, Iloilo	18.20		
Limestone cave near Guimaras	23.12		
Limestone cave near Norzagaray, Bulacan	6.73		
Limestone cave near Pilar, Capiz[a]	4.07	2.13	
Limestone cave near Pilar, Capiz[b]	7.58	1.72	
Limestone cave near Batangas	4.28	8.51	
Guano, locality unknown	19.58	0.36	0.27

[a] Sample from surface of deposit. [b] Sample from a depth of 1 meter.

Other nonmetallic minerals which have received attention during the past year but of which no production is recorded are mica, talc, and asbestos in Ilocos Norte, moulding sand in the vicinity of Manila, and a lithographic limestone near Angat, Bulacan. Prospecting and investigation have continued actively on the asbestos occurrences in Ilocos Norte; described by Smith.[4]

Manila foundries which formerly imported moulding sand have recently found local sands that serve their purposes for both moulds and cores. The most satisfactory sand for this use has been taken from the Pasig River near Pandacan, but a beach sand from the entrance to Manila Bay has also been employed. These sands mould well, but tend to burn when exposed in thin edges to the hot metal.

A fine-grained, thin-bedded limestone from Angat, Bulacan, is being exploited as a lithographing stone. Claims were located in March, 1912, by an association formed in Manila. There is a demand for lithographic stone in connection with the tobacco industry for lithographing cigar bands, cigarette packages, and cigar box wrappings. This work does not require a particularly fine line impression nor large plates, and for it the Angat stone is probably quite suitable. The local stone is slightly harder

[4] *Phil. Journ. Sci., Sec. A* (1907), 2, 145.

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than the widely used Bavarian lithographic stone and contains patches of metamorphic minerals in some places which spoil the even texture. However, careful sorting should make it possible to get out a considerable quantity of acceptable stone, and the industry promises to develop.

Mineral and artesian water.—Mineral water, artificially carbonated, is bottled at Los Baños, Laguna. The value of the combined output of the several companies, exclusive of bottles, was about 60,000 pesos in 1911. At many other places mineral springs are exploited as popular bathing resorts.

The Bureau of Public Works has completed 224 drilled wells in 1911 according to the record of the artesian well division. Of this number 120 were nonflowing wells, but were satisfactory pumping wells, 63 were flowing wells, and 41 wells were unsuccessful. Most of the flowing wells so far obtained are located in the great central valley of Luzon and are comparatively shallow, generally between 30 and 90 meters in depth.

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COAL RESOURCES OF THE PHILIPPINES.

By F. A. DALBURG.

INTRODUCTION.

The coal resources of the Philippine Islands have been investigated only to a very limited extent. Coal has been reported from nearly every island in the Archipelago and the most important fields have been visited and samples taken for analysis. Geologic surveys and investigations have been made in several fields, but these, for the most part, have been of a preliminary nature and, while they have yielded important facts regarding the occurrence and distribution of the coal deposits, they do not furnish the minute knowledge essential for quantitative determination. This article is intended to present a concise report on the extent of the coal areas, the amount of coal reserves, and the distribution of the coal fields.

An historical summary and a discussion of the geological occurrence of coal appeared in Mineral Resources for 1910.[1] The chemical and physical qualities of the coal, as determinative of technical utilization, have been described in former publications of the Bureau of Science.[2]

EXTENT AND DISTRIBUTION OF COAL FIELDS.

Coal deposits have been discovered in the Provinces of Cagayan, Abra, Rizal, Tayabas, Camarines, Albay, and Sorsogon on the Island of Luzon; and on the Islands of Cebu, Batan, Polillo, Mindanao, Masbate, Mindoro, Samar, Negros, and Dinagat.

The coal fields can be considered under six general geographic localities:

1. Batan, 2. Cebu, 3. Polillo, 4. Mindanao, 5. Masbate, 6. Mindoro.

[1] *Min. Resources P. I. for 1910, Bur. Sci., Div. Min.* (1911), 37.

[2] *Phil. Journ. Sci., Sec. A* (1907), 2, 41, 400. *Ibid. Sec. A* (1908), 3, 201. *Min. Resources P. I. for 1907, Bur. Sci., Div. Min.* (1908), 34.

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These divisions are based also upon the possibility of commercial exploitation. For instance, the Batan field is situated near sea level with only 750 meters haul from the mine to tide water, with good harbor facilities. The Cebu field, on the other hand, would require from 12 to 24 kilometers of railroad for development. The Polillo coal, although of a good quality, is off the main traveled route of steamers and is without a favorable natural harbor. The remaining fields also have difficult transportation facilities.

Table I gives the principal coal localities in the Archipelago.

TABLE I.—*Location of principal coal fields in the Philippines.*

District.	Location.	Province.	Island.
East Batan	Batan Island	Albay	Batan.
Liguan			
Calanaga			
Camujumayan (Lantauan)	Near Danao	Cebu	Cebu.
Camansi	do		
Mt. Licos	Near Compostela		
Uling	Near Naga		
Burdeus	Polillo Island	Tayabas	Polillo.
Alat River	Sibuguey Bay	Moro	Mindanao.
Nabangig	Cataingan	Sorsogon	Masbate.
Dimas Alang	do	do	Do.
Cawacat River	Bulalacao	Mindoro	Mindoro.
Gatbo	Sugud	Sorsogon	Luzon.

As only small portions of the several coal fields have been surveyed geologically, it is evident that any calculation of tonnage from the known area should give a minimum quantity of coal. The known coal fields contain a total area of about 137 square kilometers. Future surveys will no doubt show that the coal area is much greater. An estimate covering the actually known coal lands, those which are known to be underlain by coal of a quality and thickness and at a depth which makes mining practicable gives an area of less than 18 square kilometers. In this classification only quality, quantity, and depth of coal below the surface are taken into consideration. It is evident that so far as development is concerned the accessibility of the coal and possibility of marketing it are just as important as the factors mentioned above.

TONNAGE AND CLASSIFICATION.

Any estimate of the coal resources expressed in tonnage will necessarily indicate the minimum quantity and can not show the ultimate coal resources of the Archipelago. Even where surveys have been made, a large factor of uncertainty still exists, as the coal seams dip at all angles up to 90° and are folded and faulted. Then, too, numerous seams have been known to thin out and disappear. The areas used in making the estimate are small and

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possibly will be subject to great extension in the light of subsequent information.

There is almost no data available from private sources, as extensive mining or prospecting operations which form an important element in the estimates of coal resources have not been carried on and other information which might be of use has been withheld from the Government.

The figures given in Table II show approximately the areas and tonnages of the Philippine coal fields. The statement includes all coal of economic value in seams containing not less than 30 centimeters of merchantable coal and situated within a mineable depth; that is, not more than 1,220 meters below the surface. The quantities are stated as: 1, Actual tonnage, based on a knowledge of the actual thickness and extent of the seams; 2, probable tonnage, based on an approximate estimate; and 3, possible tonnage, for which an estimate in figures can not be given.

The classification of Philippine coals is based primarily on their difference in physical character with regard to color, manner of weathering, and adaptability to a particular use. From the ultimate and approximate chemical analyses available, extensive use has been made of the various ratios as employed by the United States Geological Survey and the Canadian department of mines.

Using these different criteria, the total tonnage of the various classes of coal occurs in the following proportions:

	Metric tons.
Bituminous:	
Burdeus	1,331,200
Sibuguey	3,628,000
Sub-bituminous:	
Liguan	277,600
Camujumayan	14,592,000
Camansi	4,505,600
Mount Licos	5,352,000
Uling	5,792,000
Sugud	154,000
Masbate	612,000
Lignite (black):	
East Batan	24,300,000
Calanaga	2,560,000
Bulalacao	4,096,000
Summary:	
Bituminous	4,959,200
Sub-bituminous	31,285,200
Lignite (black)	30,956,000
Total	67,200,400

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TABLE II.—*Estimate of areas and tonnage, Philippine coal fields.*

Fields.	Class of coal.	Coal seams.		Tonnage in metric tons.			Coal lands (areas actually containing marketable coal).	Coal lands (areas probably containing coal).	Coal fields (areas possibly containing coal).
		Number.	Thickness.	Actual.	Probable.	Possible.			
			Meters.				*Sq. km.*	*Sq. km.*	*Sq. km.*
East Batan	Lignite (black)	2	1.5	3,340,000	20,960,000	Moderate	2.0	5.00	15.5
Liguan	Sub-bituminous	8	a 10.5	61,600	216,000	Small	0.3	0.60	5
Calanaga	Lignite (black)	4	a 5		2,560,000	Moderate		1.25	13
Camujumayan	Sub-bituminous	4	a 9		14,592,000	Small		2.50	5
Camansi	do	4	a 5		4,505,600	do		1.25	15.5
Mount Licos	do	4	a 4.5		5,352,000	do		1.25	23
Uling	do	3	a 8	800,000	4,992,000	do	0.3	1.25	13
Burdeus	Bituminous	2	1.2		1,331,200	do		0.30	18
Cataingan	Sub-bituminous	3	1.5		612,000	do		0.60	5
Sibuguey	Bituminous	2	2.5		3,628,000	do		0.60	5
Bulalacao	Lignite (black)	6	a 12		4,096,000	do		0.30	8
Sugud	Sub-bituminous	3	a 5	154,000		do	0.1	5.00	10

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COAL FIELDS.

Batan Island is one of the two fields containing the largest amount of coal. It lies 20 kilometers northeast of Legaspi, Albay, and has an area of nearly 103 square kilometers. As far as known the coal-bearing area contains 28.5 square kilometers underlain by black lignite seams estimated to contain 26,860,000 tons, and 5 square kilometers underlain by sub-bituminous coal seams which have an estimated content of 277,600 tons. The workable coal beds range from 2 to 8 in number at different localities on the island and average from 1 to 4 meters in thickness.

Cebu Island.—The Cebu field is probably the most promising in the Islands. This field is situated on the eastern side of the Cordillera which traverses the central portion of Cebu. It extends from Mount Lantauan on the north to Mount Alpaco on the south and embraces an area of coal-bearing rocks of nearly 207 square kilometers. The distance from tide water is 12 to 25 kilometers. The coals of this field are sub-bituminous. The largest areas and those which have been most extensively prospected and worked are:

1, Camujumayan; 2, Camansi; 3, Mount Licos; 4, Uling.

The Camujumayan district is a narrow basin with a strike of nearly north 45° east, each limb of the syncline dipping 35°. The area is estimated at 7.5 square kilometers with a thickness of 10 meters of coal in the section. This would give a probable coal content for the area of 14,592,000 tons.

The Camansi district is situated 14 kilometers due west from Danao on the east coast of Cebu. The coal seams are four in number and have an aggregate thickness of 5 meters. The total area of available coal is not over 17 square kilometers with a content of 4,505,600 tons.

The Mount Licos district is about 10 kilometers due west from Compostela, which is just south of Danao on the east coast. The general strike of the coal measures is north 25° east with dips to the southeast from 30° to 90°. There are four seams in the section with a total thickness of 5 meters. The possible area is 25 square kilometers with a probable coal content of 5,352,000 tons and a possible area greatly in excess of 25 square kilometers.

The Uling district is situated 12 kilometers northwest from Naga, which is also on the east coast about 20 kilometers south of the City of Cebu. The coal-bearing rocks are slightly flexed and folded and are monoclinal. The conditions are such that continuity can not be depended upon. The strike is nearly north

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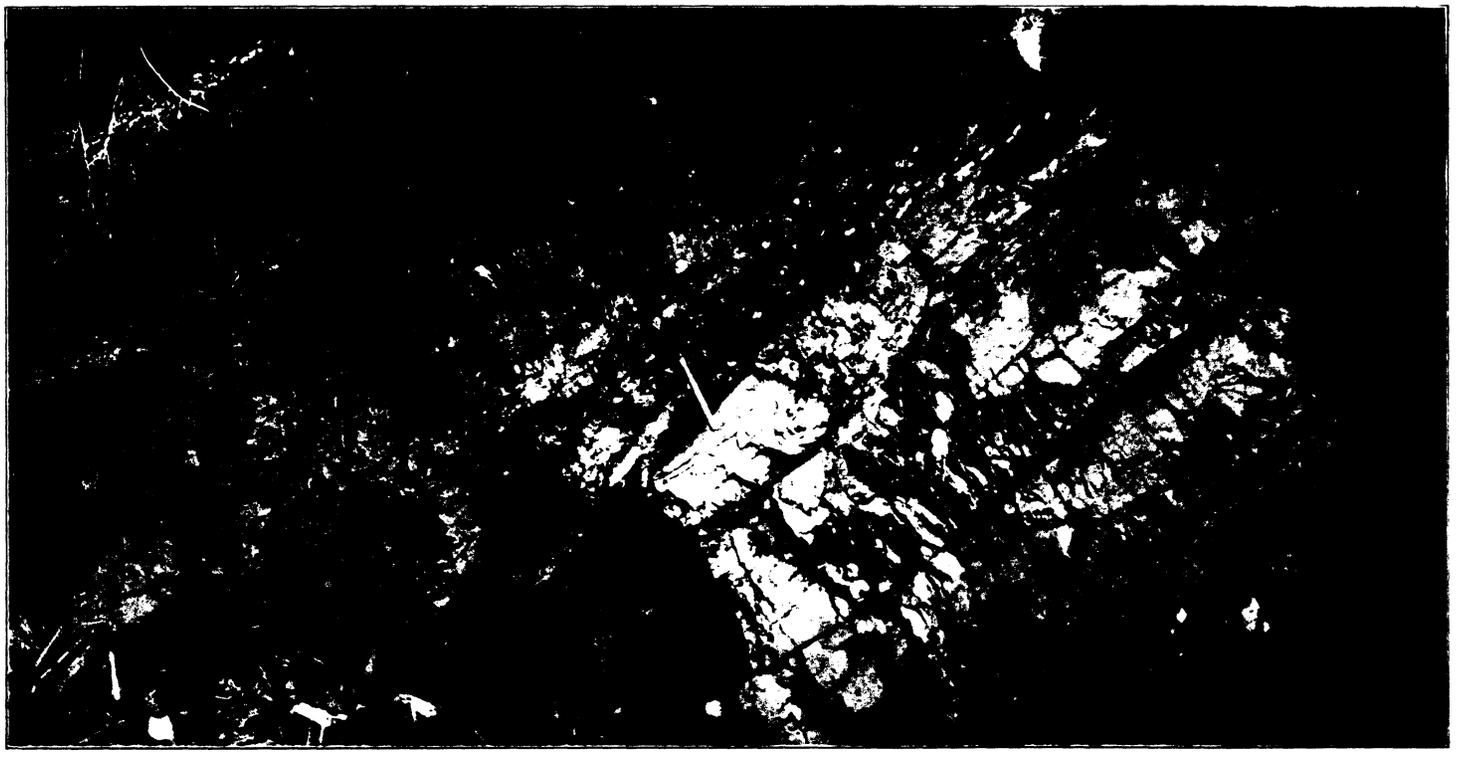

PLATE VI. AN OUTCROP OF COAL, NACIPIT CREEK, ULING COAL FIELD, CEBU. THIS SEAM IS 4.75 METERS THICK AND DIPS TO THE WEST AT AN ANGLE OF ABOUT 40 .

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15° east and the beds dip at angles from 30° to 40°, to the westward. Three seams are known to exist from 0.5 to 4.5 meters in thickness. The area is 14 square kilometers and the possible coal content 5,792,000 tons.

Polillo Island lies 24 kilometers off the eastern coast of Luzon at nearly the same latitude as Manila. The Burdeus district is situated on the eastern side of the Island between Burdeus and the Anibauan River. The district is off any regular line of steamers and on a bad coast. The best outcrops have been found on Guinibuan Creek and vary in thickness from a few centimeters to 2 meters. As far as known only 2 seams occur within a workable depth. The area is estimated at 18 square kilometers with a thickness of 3.5 meters of coal. The probable content is 1,331,200 tons of bituminous coal.

Mindanao Island.—The Sibuguey district is northeast of Zamboanga about 233 kilometers and 8 kilometers from tide water. There are two seams of bituminous coal, 1.5 to 2.5 meters thick. It is impossible to make any just estimate of the total amount of coal for lack of data, but there is probably an area of 5 square kilometers of coal-bearing rocks with 0.5 square kilometer underlain by coal. The content is estimated to be 3,628,000 tons. The possible area is large.

Masbate Island.—This field is situated in the southeastern part of Masbate, nearly 15 kilometers distant from Cataingan Bay. Three distinct seams occur having from 1 to 1.5 meters thickness, of sub-bituminous coal. The area is about 5 square kilometers and is estimated to have a probable coal content of 612,000 tons.

Mindoro Island.—The Bulalacao district is situated in the southeastern part of the Island of Mindoro and is 10 kilometers from tide water. The seams are reported to be from 1 to 4 meters thick covering an area of nearly 8 square kilometers. The coal is a black lignite, and the content of the field is estimated at 4,096,000 tons.

Sugud district (Gatbo) is situated in the southeastern part of Luzon on Sugud Bay. The coal seams are nearly vertical with a north 20° west strike. The seams are from 3 to 8.5 meters wide. The area of coal bearing rocks is approximately 16 square kilometers, but the seams are nearly vertical and broken. The coal content is estimated at 154,000 tons of sub-bituminous coal.

MARKET AND COAL CONSUMPTION.

There is a large market for coal within the Philippine Islands themselves. Over 500,000 tons are used annually by the inter-

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island steamers, railroads, United States Army and Navy, and industrial plants. Most of the coal used at present is imported from Japan and Australia. The price which coal commands in the Islands varies from 8 to 14 pesos per ton.

Coal in Australia can be mined at the northern collieries for 2.02 pesos per ton. Some of these mines are situated near tide water and the coal can be delivered on board ship at from 3.56 to 5.34 pesos per ton. In Japan coal is mined for approximately 3 pesos per ton and sold on board ship for from 5.20 to 9.60 pesos per ton.

Coal has been mined in the Philippines for about the same cost as given above, but for short periods only. The reason for this is that the mines have not been sufficiently developed underground to insure a steady output through several years of mining. Philippine coal is sold at from 6 to 10 pesos per ton in the open market.

In Table III, the quantity and value of coal and coke imported and produced since 1908 are given.

TABLE III.—*Coal and coke imported into the Philippine Islands, 1908–1911.*

COAL (SUBJECT TO DUTY).

[Weights in metric tons; values in pesos, Philippine currency.]

Countries.	1908[a]		1909[a]		1910[a]		1911[a]	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
China	41	430	43	260	110	1,216	1	6
East Indies:								
British	2,197	19,966	1,601	11,692	26,200	164,230	17,317	109,110
Dutch					1,295	8,676	8,617	37,750
French			32	388				
Japan	3,391	28,480	293	2,114	101,603	823,114	166,426	1,303,592
Australia	208,316	1,085,420	171,866	908,476	178,775	947,546	233,175	1,144,330
United States	12	126						
Africa	2	18						
Total	213,958	1,134,400	173,835	922,930	307,983	1,944,682	413,736	2,594,788

COKE (SUBJECT TO DUTY).

[Weights in metric tons; values in pesos, Philippine currency.]

Countries.	1908[a]		1909[a]		1910[a]		1911[a]	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
United States			59	734	4	144	160	4,386
United Kingdom	4	182	25	686			10	310
China	17	612			1	30	2	62
Hongkong	6	204	8	18	11	526	29	340
Japan	2,915	30,968	9	322	263	4,678	170	3,070
Australia	219	3,644	343	4,900	759	10,100	1,158	17,812
Total	3,158	35,610	444	6,902	1,038	15,138	1,529	26,644

[a] Twelve months ending June 30.

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COAL IMPORTED INTO THE PHILIPPINE ISLANDS FREE OF DUTY.

[Weights in metric tons; values in pesos, Philippine currency.]

Manila Railroad Co.	2,054	10,252	2,019	11,642	3,203	17,218	2,468	12,790
Philippine Railway Co.	5,475	22,644	8,292	42,154	12,307	81,944	8,123	47,374
Insular Government	46,560	[b]279,360	40,519	[b]243,114				
United States Government	226,162	[b]1,356,972	173,781	[b]1,042,686	104,054	644,166	93,999	502,086
Total	280,251	1,673,198	224,611	1,339,596	119,564	743,328	104,590	562,230

SUMMARY OF COAL CONSUMPTION OF THE PHILIPPINE ISLANDS.

[Weights in metric tons; values in pesos, Philippine currency.]

Imported:								
Subject to duty	213,958	1,134,400	173,835	922,930	307,983	1,944,682	413,736	2,594,788
Free of duty	280,251	1,673,198	224,611	1,339,596	119,564	743,328	104,590	562,230
Produced in the Philippines	10,035	77,166	30,336	197,184	27,969	176,255	[b]20,000	130,000
Total	504,244	2,884,764	428,782	2,459,710	455,516	2,864,265	548,326	3,287,018

[b] Estimated.

DEVELOPMENT AND PRODUCTION.

Although coal has been known to exist in the Philippines for over eighty-five years, the amount of mining has been insignificant. During the last year two coal companies have been in actual operation and producing coal.

The East Batan Coal Co. mine is not working to its full capacity, but is awaiting further development underground.

The total production, since 1842, is shown in the following table:

TABLE IV.—*Coal production of the Philippine Islands from 1842 to 1911.*

Years.	Metric tons.	Value.
		Pesos.
1842 to 1906	[a]30,000	450,000
1907	4,123	26,800
1908	10,035	77,166
1909	30,336	197,184
1910	28,655	176,255
1911	[a]20,000	130,000

[a] Estimated.

New discoveries of coal have been reported in 1911 from Bayombong, Nueva Vizcaya; Llorente and Wright, Samar; San Isidro, Leyte; and Tabasp, Occidental Negros. Nothing is known of these occurrences except that the seams vary from a few centimeters to 3 meters in thickness. The samples obtained show a grade of coal varying from black lignite to sub-bituminous.

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The samples submitted from Samar show the following analyses:

Constituent.	Sample from Wright.	Sample from Llorente.
	Per cent.	*Per cent.*
Moisture	16.78	12.43
Volatile	37.75	31.43
Fixed carbon	36.53	30.46
Ash	9.54	25.68
Total	100.00	100.00
Sulphur separately determined	2.32	10.57

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THE SALT INDUSTRY AND RESOURCES OF THE PHILIPPINE ISLANDS.[1]

By ALVIN J. COX.

INTRODUCTION.

Common salt or simply salt is the name applied to the industrial and natural forms of sodium chloride (NaCl). The salt industry is an important one and as it supplies a very necessary article of food directly affects every individual. In the United States and in England it is estimated that about 9 kilograms of salt per capita are used annually, directly or indirectly for food. The consumption per capita in the Philippines is probably not more than one-half of this amount. The use of common salt other than for domestic purposes is very large. It has a great many applications as a preservative and in different chemical and metallurgical processes.

SOURCE AND CHEMISTRY OF THE BRINE.

Common salt (NaCl) is widely distributed in nature. It occurs in solution in sea water and in salt springs and in solid form as rock salt.

The concentration of the salt dissolved in the water of the different seas is variable, depending on the conditions of dilution and concentration by evaporation. An especially good example of the latter is Great Salt Lake, Utah, which contains 21 parts of salt in 100 parts of water. The Mediterranean contains 3.8, the Atlantic Ocean 3.6, the Pacific Ocean 3.5, and the Baltic Sea 0.5 parts of salt in 100 parts of water.

In spite of large individual variations, sea water contains on the average about 3.5 parts of salt. A reservoir 12 by 16.7 by 5.5 meters filled with sea water would contain about 40 tons of salt, and it has been calculated that if all oceans and seas were evaporated to dryness there would be obtained a quantity of rock salt equal to fourteen and one-half times the continent of Europe above sea level.

[1] Delivered before the Manila Merchants' Association, February 23, 1912.

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CHEMISTRY OF THE BRINE.

Besides sodium chloride, sea water contains small quantities of other salts such as calcium, magnesium and potassium sulphates, chloride, and bromides. For this reason the chemistry of brine is complex and involves a unique study of chemical equilibrii. For the practical purposes of salt manufacture, however, the chemistry is quite simple. We have in most cases but one valuable constituent, the sodium chloride, to be separated from the obnoxious ingredients.

When sea water is evaporated at ordinary temperatures the first precipitation begins at a specific gravity of 1.05 and consists of calcium carbonate or limestone together with small quantities of hydrated oxide of iron, oxide of manganese, alumina, silica, and some few other impurities. These are all precipitated before a specific gravity of 1.13 is attained, whereas the deposition of gypsum or sulphate of lime begins at this concentration. Gypsum is the only constituent of sea water less soluble than the common salt which is difficult to get rid of, and it must always be removed as completely as practicable before the sodium chloride is deposited.

Gypsum is least soluble in brine when the concentration is as great as possible. Three-fourths of it are deposited between the specific gravities of 1.13 and 1.21, whereas at the latter gravity the brine has just reached the saturation point with respect to common salt. The remaining one-fourth of the gypsum separates out with the salt, but constitutes so small a part of the whole that the commercial value of the latter is not appreciably lowered. Deposition of 95 per cent of the sodium chloride occurs in concentrating the brine from a specific gravity of 1.21 to the point where the formation of magnesium sulphate begins.

With further concentration some of the bitter salts, principally Epsom salts and carnallite will be precipitated with the remainder of the sodium chloride. Magnesium chloride and bromide, which are also present, are not actually deposited, but remain in solution under ordinary atmospheric conditions.

It is evident that the manipulation of the brine should be a progression; the separation of the gypsum should precede and, in so far as possible, be independent of the crystallization of the sodium chloride, and the concentration by evaporation should cease before the bitter salts begin to deposit. To eliminate the gypsum and to obtain the salt as completely, as purely, and as cheaply as possible, is the end in view for all manufacturing processes. In the laboratory, it is very easy to do this, but in commercial practice any operation employed must be very inex-

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pensive and the cost of any chemical method which has been proposed is too great to permit its general use. Thus far, concentration and the application of heat are the only means which have been employed to hasten the deposition of gypsum.

HISTORICAL.

The solar evaporation of sea water is of ancient origin. Pliny relates that six hundred years before Christ the first sea water was led into closed basins to evaporate for salt. The beginning of the salt industry in the Philippines is obscure. As long as the Islands have been inhabited, it is probable that every family along the sea border was its own salt maker. Although it is impossible to determine just when the first attempt at commercial salt making was undertaken in the Archipelago, Spanish writers referred to it as an occupation over three hundred years ago. The industry has been more highly developed by the Tagalogs than by any other Filipino peoples.

SALT-MAKING PROCESSES.

All processes for salt-making fall into three groups, depending on the character of the heat employed and the manner of its application: (1) Use of solar heat, or solar salt manufacture; (2) direct artificial heat, or kettle and pan process; (3) steam heat or grainer methods. The majority of the plants in the Philippine Islands belong to the solar group; there are a few kettle plants and no steam plants.

USE OF SOLAR HEAT IN DIFFERENT PROCESSES.

In warm climates, as upon the shores of the Mediterranean, the coasts of California and Mexico, the entire Pacific coast of South America, the islands of the West Indies, southern Australia, and the whole coast line of tropical Asia, including China and Japan, sodium chloride is obtained by the evaporation of sea water on the tide lands, or in the shallow lagoons, or in shallow basins or pools constructed upon the sea shore and exposed to the sun's rays. Salt produced in this way is called "bay salt" or "sea salt."

In many countries the production of salt is a state monopoly, or is under government control. The salterns or salt farms are either leased to private companies or administered directly by the officials of the government.

Since American occupation all restrictions on the manufacture of salt in the Philippines have been withdrawn.

Solar evaporation must be carried on in general where it is hot and where evaporation greatly exceeds the rainfall; that is,

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where there is a pronounced dry season. In the eastern half of the Philippine Archipelago, the rainfall is more or less equitably distributed throughout the year, hence the principal works are confined to the western portion of the Islands where there is a definite dry season.

At present salt is prepared in the Philippines in large quantities by a very crude and simple process from sea water. Large areas of sandy land along the coast approximately at the level of high tide are available for evaporating salt water. The surface of this is loosened and water from canals, through which it is led in from the sea, is sprinkled over the area by hand, where it rapidly evaporates. This process is repeated about four times per day for three days until a quantity of salt has accumulated in the loose earth. On the fifth day this salt-impregnated earth is scraped into heaps and collected into leaching vats.

The leaching vat is lined with clay to prevent leakage except at one point where the water is purposely allowed to escape through a bamboo spout into a cement, earthenware, or clay-lined well. The leaching is performed with sea water poured on to a filter so that the loose earth will not be displaced. On top of the clay is placed a layer of palm leaves or rice husks which filters the mud from the brine and allows the filtered brine to circulate freely downward into the well. The brine is then dipped back into the leach and the operation repeated until it becomes strong, when it is transferred to shallow crystallizing ponds.

The style of the leach depends on the locality. In some places a leaching vat is built on the ground, but high enough so that the leached mud may be removed by gravity after the process is completed. In others, after the leached mud has hardened slightly, it is marked off into squares. While the leaching is in progress, another layer of loose earth is being impregnated. This is scraped into heaps about the leach, while the squares of leached mud are drying. When the blocks have sufficiently hardened, they are thrown from the leach back on to the field. After the second crop of salty earth has been scraped into the leach, the clods are pulverized and carefully spread out to be again impregnated.

The amount of salt in brine is usually determined by a salometer, a hydrometer (or splindle), which gives a direct reading of the percentage of the salt in solution by having the point to which it sinks in pure water marked O and the point to which it sinks in saturated brine marked 100. In the Philippines there are many salt water shurbs and trees which when green have a specific gravity greater than that of water. It is common prac-

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tice among the Filipinos to pluck twigs of the plant known locally as *sulase* (*Lumnitzera racemosa* Willd.) which grows in the marshes near the salt farms and along the levees of the evaporation reservoirs, strip them of their leaves and throw them into the brine to test its strength. If they sink, the brine is not yet strong enough; when they float, the brine is sufficiently concentrated to transfer to the crystallizing ponds. I have determined the specific gravity of the *sulase* such as they use to be about 1.085 or equivalent to 11.5 per cent of salt.

The crystallizing ponds are floored with smooth broken pottery set in lime mortar to retard seepage and to prevent the admixture of sand with the salt. The salt crystals are readily removed from this floor. The ponds are surrounded with bamboo fences covered with *nipa* or *cogon* grass, in order to prevent the prevailing wind from blowing dust into them and to prevent the floating crystals from congregating on the leeward side.

This method for the manufacture of salt has been used as long as any of those now employed in the industry can remember and is probably the original method used in these Islands. By this process gypsum is largely eliminated, for it is not readily soluble and but little of it is redissolved in the leaches.

A modification of this method is sometimes though seldom used where the land is below tide level. In such a case the depression is levelled, enclosed by dykes, and filled with sea water which is evaporated by the sun's rays; when the water has disappeared, the surface crust is gathered up and leached as above described.

Another method in use in the Philippines, introduced in recent years by the Chinese, utilizes most of the lower areas—the vast stretches of over-flowed tide lands, or salt marshes, at the heads of the bays or along the coastline. The land best suited is that flush with an ordinary tide so that it may be covered from 30 to 50 centimeters deep by a high tide.

The land having been cleared of vegetation and débris is first leveled and then diked with levees 1 meter or more high. It is then partitioned off into reservoirs or shallow evaporation lakes or stock ponds of different sizes depending on the size of the plant itself for receiving, settling, and evaporating the sea water and precipitating the salts of lime. There are seldom less than 4 reservoirs in a series and often 6 or 7. The reservoirs in which the first evaporation takes place are usually used as fish ponds. The brine is drawn from one reservoir to another as it strengthens and decreases in volume by evaporation and new water is in turn admitted from the bay to the first reservoir.

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Beyond the reservoirs, crystallizing ponds are constructed in the manner already described.

When the brine contains about 10 per cent of salt by weight and before the maximum precipitation of impurities has been attained, it is transferred from the last reservoir to the crystallizing ponds, the average dimensions of which are about 5 by 6 meters, for final evaporation. As the evaporation continues in the crystallizing ponds, more and more of the strongest brine is added. As the brine concentrates, it deposits salt, and every day after sundown, when the temperature has fallen, to give the maximum crystallization the crystals are raked off the liquid into heaps at the side of the ponds, gathered into baskets called *tiklis* to drain, and finally conveyed into warehouses. A laborer usually works from 4 to 6 of these ponds, either on shares or at a daily wage of from 60 centavos to 1 peso.

In the ideal plant the transfer of the brine from the bay to the crystallizing ponds is by gravity. When the crystallizing ponds are higher than the evaporation reservoirs, the brine is dipped up by hand from wells in the latter and transferred to the crystallizing ponds by means of buckets or other apparatus. The soil on which the crystallizing ponds are built is usually sandy, and, as the water seeps through, ditches carry it to a well from which it is bailed out with a bamboo sweep into another ditch which returns it to the evaporation reservoir containing the strongest brine. When land above tide level is employed for a greater part of the plant, the water is elevated with a bamboo sweep.

All of the salt works are reached by water transportation.

The working season for the plants along Manila Bay varies somewhat from year to year, but depending on the weather usually begins in December and continues until May, a period of approximately one hundred and fifty days. The season closes with the beginning of the rains. The product is coarse and not usually of the best quality, containing magnesium salts and other impurities.

In all of the Philippine plants using the new method the brine is transferred from the evaporating reservoirs at a density never much more than 1.13, the concentration at which gypsum begins to deposit. The effect is directly noticeable on the composition of the products which contain a high percentage of lime. The bitter salts are not removed from the crystallizing ponds in either the old or new process and the effect is evident in the high magnesia content of the salt. The brine thus treated will give a product containing 6 to 7 per cent of impurities.

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However, if the mother liquor, which contains bitter and hygroscopic salts, is removed from time to time, a much higher grade of salt may be produced.

The salt produced by the old native method has acquired a reputation for its superior qualities for curing fish. Many Filipinos say that it takes more of the salt produced by the new method to preserve a given weight of fish.

In the old process the sea water is evaporated to dryness, and in that way the lime salts are more completely removed than is now common practice in the new method where the brine is carried to the crystallizing ponds too soon. By the old method particularly, the salt was usually retained in warehouses for some time. With the new method salt is produced in large quantity and is frequently sold directly after draining and before the pile has weathered and the hygroscopic salts have been washed out by the absorption of moisture from the air. These are the only differences between the two products. With proper manipulation the salt produced by the new method will have as high a percentage of purity as that produced by the Filipino method.

The Ilocanos in some places have developed a process of their own. A fire is built on the beach and sea water continually sprinkled on, just enough not to put out the fire. Finally, the fire is allowed to burn out, the ashes are leached with sea water, and the leachings evaporated by artificial heat in *cauas*, or huge, thick, iron pans or kettles mounted on rude clay furnaces. The crystals produced by boiling are formed rapidly and are therefore not so large nor so hard nor so desirable for packing purposes as those produced by slow evaporation.

USE OF ARTIFICIAL HEAT IN KETTLE OR PAN PROCESSES.

The salt supply of the Mountain Province for the greater part comes from the lowlands through Cervantes. The article is sold to the people at exorbitant prices. The people of the Mountain Province also produce a certain amount of a poor grade of salt by evaporating water from the carbonated brackish springs at Mayinit, Bontoc; Tukukan, Ahin, and Bungú-bungna, Ifugao; and Salina, Nueva Vizcaya.

It is not known just when the salt springs were discovered. The supply of brine varies in quantity and in strength. The result of the abnormal price is that in certain places at certain times of the year the entire supply of the brine is used for boiling by operators who take turns at the spring.

Most of the plants now used are very much like those de-

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scribed in ancient history. They consist of a few *cauas,* or kettles, obtained from the Ilocanos, mounted on crude furnaces built of stone and clay. There are no furnaces with a large number of kettles and often there is only one kettle to a furnace. At present there is little attention paid to the economy of heat, though eventually the success or failure of the process will depend on whether or not there is economical application and thorough utilization. The salt obtained in this way is very inferior, as no method is adopted to separate the salt from the mother liquor or other impurities either organic or inorganic. One laborer can attend to one kettle and produce about 12 kilograms of salt per day. By the old solar method the average daily production per laborer varies from 14 to 85 kilograms of salt, depending on the locality and the refinement of the process, while the average production for the new process is about 200 kilograms of salt per laborer per day.

At Mayinit the salt water is hot, contains 0.3 per cent of salt, and flows from the spring in several shallow streams. Salt houses are built over carefully leveled plots of clayey soil upon which water from the streams is led. There are more than 100 such houses, usually about 4 meters wide and from 4 to 8 meters long, with grass-covered roofs extending to the earth. The ground space of the salt house is covered with stones from 10 to 15 centimeters in diameter. The hot water is allowed to spread out and pass among the bases of these stones from where it is carried up on the stones by capillarity and evaporates fairly rapidly from the exposed hot surfaces, leaving a thin crust of salt.

About once each month the salt is gathered by washing the encrustation from the stones into a large wooded trough called a *ko-long-ko.* After each stone has been thoroughly washed, it is replaced in the house. The saturated brine is preserved until a sufficient quantity is gathered for evaporation, when it is boiled as above described. The product is pressed into cakes and placed upon bits of broken earthenware and baked either in the fire or in the sun.

The dried salt contains about 13 per cent impurities.

The flow of the spring at Tukukan and at Ahin is probably 500 liters per hour each and contains 0.6 and 1.2 per cent of salt respectively. The Tukukan spring is rather inaccessible, but that at Ahin is on the bank of the river down which is floated the necessary wood for the furnaces, cut from the pine forests above. The latter spring comes from a crevice in the solid rock and could probably be developed.

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In July, 1910, there were a dozen kettles in operation which consumed the entire output of the spring at Bungú-bungna.

When the salt has been evaporated to a semi-solid condition, it is made up into packages and the drying is completed by placing these on the hot rocks of the furnace. These contain about 350 grams each and sell for a peseta [1] apiece.

At Salina the sight of the two springs is a wonderful one aside from the salt making operations. The brine comes from the springs in the side of the mountain highly charged with carbon dioxide under which condition it carries, besides 3.2 per cent of salt, large quantities of lime and some iron in solution. On reaching the surface where the pressure is released the carbonate of lime is deposited and in this way the springs have build up huge mounds of mineral deposits.

A portion of the water is collected and carried nearly 2 kilometers through troughs made of split bamboo. These are quite rapidly coated with sulphate and carbonate of lime in that portion of the line nearest the spring, the amount of coating decreasing fairly rapidly with distance. In fact the objects of carrying the water so far through open troughs are: first, to get rid of the undesirable substances which precipitate before the salt, and, second, in order that firewood may be closer at hand for the boiling. Hardwood logs are used for fuel and are shoved in from both sides of the furnace so that the points meet at the center. As the points burn off the logs are shoved in farther. Practically the only cost of producing salt here is the cost of getting out the wood. About 70 pans were in operation in June, 1911.

Only a small part of the water which is at present flowing from these springs is utilized, yet it furnishes 125,000 kilograms of salt annually for a population of about 50,000 people so there ought to be an opportunity for doing away with kettles and open pans and starting a modern concentration plant with steam heat.

In general when kettles and open pans are used they are placed over a long combustion chamber in direct contact with the flames from the furnace. The heating is not uniform. The removal of the gypsum depends upon a quiet, regular boil of the liquid which can not be uniformly obtained in all the kettles of a block, and therefore the quality of the salt is variable. Furthermore, the heat causes the calcium sulphate to form a hard scale which clings to the kettle, and thus reduces the efficiency. Steam heat is more frequently used when vacuum pans are employed. The

[1] One peso (100 centavos) Philippine currency is equal to 50 cents United States currency. One peseta is 20 centavos.

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grainer process requires steam heat exclusively. The steam is carried through pipes submerged in the brine. The temperature is varied by varying the pressure, so as to obtain salt having the desired grain. This process is now much more generally used in the United States than any other. The general result is that a better quality of salt is produced and about 50 per cent more evaporation is effected by a given quantity of fuel, when it is fired under a properly constructed boiler to produce steam for heating purposes, than in any other way. There is coal in Nueva Ecija and coal is even a better fuel for salt vacuum-pan or grainer units than wood.

PRODUCTION AND IMPORTATIONS.

Few statistics of the salt produced in the Philippines have been kept. Information from municipal presidents shows that there were over 100 municipalities in about 20 provinces producing salt by the evaporation of sea water with solar heat in 1910–11, and that in round numbers 20,000,000 kilograms of coarse salt were produced. Thirty-five per cent of the total amount was produced in the Province of Rizal. Since there is no exact basis of comparison, it is impossible to prove a large increase in the local production, though the value of last year's production was nearly twice that given for 1903 in the Census of the Philippine Islands.

Formerly the Philippines produced practically enough salt for domestic consumption. This is no longer true. The local production does not keep pace with the growth of the packing industry. By actual count in 1907 there were but 5 Chinamen engaged in packing sardines in Tondo, but before the great Tondo fire of last year there were 36 in this business in that section of the city, each using large amounts of coarse salt. Since 1907 there have been no exportations of salt and the importations have increased from 6,070 pesos in 1908 to 122,210 pesos in 1911 and there is every evidence that this is in the face of increased production. The principal importations are from China which sends only coarse salt in shipments of from 1- to 300-bag lots. The production of salt in the Philippines ought to be increased and improved so as to reduce and more perfectly compete with this importation; furthermore, with Manila's good dock facilities there is the possibility of increasing the number of industries using common salt. Sardine canneries and other similar commercial packing industries could be developed and increased if an abundant and cheap supply of salt were assured.

The various elements which make up the cost of an article of

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commerce are found exemplified in the simplest and clearest manner in the salt industry of the Philippines.

The raw material, sea water, is without cost, and the cost of the salt depends upon the unskilled labor needed to produce it and the interest on the investment in the plant. The cost of implements is less than for any other industry. The introduction of the use of reservoirs for evaporating the sea water is in the nature of a labor-saving device.

SALT MILLING.

So far as I have been able to determine there have been no attempts at salt milling in the Islands, and the only product has been coarse salt. There has been sufficient demand from *tiendas* and packers to consume it all in this form. A modern mill might be profitable after the output has been very largely increased.

BY-PRODUCTS.

In the Philippines, no effort is made to derive a profit from the by-products. In certain localities in the United States the entire profit of the salt industry has been from by-products. In fact in some plants the salt alone is made at a financial loss, but the bromine and calcium chloride have yielded sufficient returns to keep the furnaces active.

The bromine is liberated as a vapor by means of chemicals from the hot bitterns and is liquified in a condenser.

After the bromine has been removed, the liquid is treated with lime and then concentrated by boiling in an open pan. The process is completed in kettles containing steam coils, the calcium chloride remaining as a thick liquid which solidifies on cooling.

Bromine is used for metallurgical purposes, in photography, in the color industry, in medicines, especially as potassium and sodium bromides, and as an oxydizing agent, and is worth about 2 pesos per kilogram. I doubt if the manufacture of calcium chloride in the Philippines would be a financial success, for the local demand is small and since it is a cheap product, worth only about 8 centavos per kilogram, there would be little profit in shipping it to a distant market.

SUGGESTIONS.

Solar salt is manufactured at Syracuse, New York, and other places by evaporating brine on so-called covers, shallow wooden vats provided with light, movable roofs arranged in such a way that they can be easily shoved over the vats when it rains. The improved process consists in the use of "aprons," which convey the brine from the wells to the salt fields; these are very wide

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shallow troughs in complete exposure to the sun, air, and wind; and are 5 or 6 meters wide by 6 or 7 centimeters deep. Upon this, the brine kept at a depth of about 1 or 2 centimeters flows slowly, depositing the gypsum and being delivered in a saturated condition to the covers. The fall of brine is usually about 1 centimeter to 10 meters. Under the aprons are deep rooms, or tanks, so placed that, in case of rain, the brine on the apron can be discharged into the deep room, where it is protected from dilution, remaining there until the return of fair weather, when it is pumped back into the apron, from which all rain water has been drained. With this improvement, the efficiency of a cover has been increased over 80 per cent in many instances. Natural brines, which are sometimes very dilute, are often concentrated by dripping over extensive ricks composed of twigs. In the Philippines where *nipa* and grass roofs are so cheap and comparatively durable, I believe a great deal might be done in the adaption and utilization of these ideas. For instance, the past season illustrates what may be accomplished in this direction. During the period from December 1, 1910, to May 31, 1911, more than half of the water evaporated from the ponds was returned to them by rain, so that operations on the salt farms were much interfered with and at times suspended. Out of the season of six months it rained on thirty-two days, and on eighteen of these days more water fell into the ponds than was evaporated from them. Even in the most favorable four months of this season more than one-fifth of the water evaporated from the ponds was returned by rain and, therefore, the effective evaporation was only four-fifths of the apparent. If the ponds had been covered during the whole period, four-fifths as much water would have been evaporated as was evaporated in free exposure. In other words, if the ponds had been covered during the whole season, the evaporation would have been at the rate of the effective evaporation during the most favorable months.

The saving by the use of covered vats may be further illustrated. A square meter of crystallizing pond originally costs about 1 peso, the annual upkeep is about 5 centavos and the annual yield is about 100 kilograms of salt. By the use of covers the average annual yield could be increased to 118.7 kilograms and in exceptional seasons to 153 kilograms with very little additional labor. The original cost of arranging movable roofs in such a way that they can be slid easily over the vats when it rains would not exceed 50 centavos per square meter and the life of the roofs would be at least five years. The increased output of an average season would return 50 per cent

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of the additional outlay, and in exceptionally favorable seasons this would be increased threefold. Furthermore, the length of the season could be considerably increased. No strong brine would ever be lost at the end of the season, as the evaporation could be finished entirely under cover, if necessary.

The fact must be recognized that the producers in general are not obtaining the best practical results. Many of them are unwilling to change their methods, while others can not without a previous study for which they have neither time nor opportunity. The foundation for such study is the collection of manufacturing statistics from the native works, and their careful comparison with each other and with the best results of foreign practice. The results of my study thus far lead to the following conclusions:—

With the same labor and the same area a plant using the most efficient process of the old method will produce only one-fifth to one-third as much salt as one using the new method. With the latter the following conditions should be observed:—

The brine should not be transferred to the crystallization ponds until salt is ready to crystallize out, for in the evaporation reservoirs large quantities of gypsum and other matter precipitated before the salt settles out and a purer grade of salt is obtained. There should be a proper relation between the crystallization pond area and the area of the evaporation reservoirs so that the brine will be delivered to the crystallization ponds in a saturated condition.

The area occupied by the crystallizing ponds should be as small as is possible to accommodate the brine concentrated in the evaporation reservoirs, for in that way one obtains as much salt with less labor. When the mother liquor in the crystallizing ponds has become so concentrated that it gives an impure salt, it should be drawn off and worked over for the by-products or discarded. Experiments show that salt with less than 0.5 per cent of impurities may be obtained with these precautions.

Effort should be made to improve the quality of the output and to develop a larger industry in the Philippines.

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SULPHUR DEPOSITS IN THE PHILIPPINE ISLANDS.

WITH EXTRACTS FROM THE REPORTS OF MAURICE E. GOODMAN AND H. G. FERGUSON.

By WARREN D. SMITH.

GENERAL CONSIDERATIONS.

Before describing these localities in detail, I shall give some general facts in connection with the sulphur industry, which bear upon commercial exploitation.

In the Philippines, as in Japan, sulphur is found in connection with extinct or dying volcanoes. In places one encounters small cones of nearly pure sulphur built up around vents from which have issued, and in some cases still issue, sulphurous gases. Also, sulphur is encountered permeating the volcanic rocks in the neighborhood of these vents. It is quite possible that boring in and about volcanic regions in the Philippines will disclose important quantities of sulphur-permeated rock. When the sulphur content is not less than 8 or 10 per cent, such material can be worked profitably where labor and transportation conditions are favorable.

We have no estimates of the quantity of sulphur available, except in the case of the Biliran Island and Leyte deposits, where Goodman, formerly of the Bureau of Science, estimated that there were possibly 3,000 tons in the three deposits in sight. Of the amount on the Island of Camiguin (north of Luzon), Ferguson, formerly of the Bureau of Science, could give no estimate, but reported that there was apparently a commercial deposit.

Mining.—The mining of sulphur is usually a simple process; ordinary quarrying methods being often resorted to. In Louisiana the sulphur is obtained by forcing hot water down specially designed wells and fusing the sulphur which is then removed as a liquid.

Refining.—The common practice in refining is a simple heat treatment, the sulphur either melting and flowing away from the gangue rock, or distilling off directly as a gas. Sulphur which has been separated by melting is usually further refined by

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distillation, the result of which is the well-known product "flowers of sulphur."

Market.—As the Japanese have built up a considerable industry, there would probably be competition in placing Philippine sulphur on the market. There are 31 localities in Japan where sulphur is mined. In these localities the sulphur occurs in very much the same manner as we find it in the Philippines.

The present price of prime domestic sulphur, as quoted in New York, is 44 pesos (22 dollars, United States currency) to 45 pesos (22.50 dollars, United States currency) a ton. A very important item should be noted in connection with the exportation of Philippine sulphur; namely, the export tax of 2 pesos a ton on Philippine ores. Sulphur would probably be classed as an ore.

DETAILED DESCRIPTION OF LOCALITIES.

BILIRAN ISLAND AND LEYTE.

The report of Goodman, formerly of this Bureau, made in January, 1906, regarding these deposits, mentions some "solfataras" near Burauen, south of Tacloban, on the Island of Leyte. Concerning the Burauen sulphur which is about 10 kilometers south of Burauen, Leyte, Goodman says:

> The source of the heat and sulphur carried by the Mainit lies in the solfatara, which is only about one-half kilometer east of where we crossed the river and about 30 meters above it. The To-od Grande, as this solfatara is called, is a large barren space about 250 meters long by 150 meters wide. Its surface consists of white kaolin resulting from the corrosion by acid fumes of some volcanic rock, probably andesite. A portion of this superficial layer has encrusted upon it a greenish yellow mixture of sulphur and clay, deposited from the sulphuric gases which still emanate from numerous fissures and crater-like openings in the surface of this barren area.
>
> These openings are of two kinds: dry vents from which gases escape into the atmosphere without the association of water, and wet holes which are like large earthen caldrons containing either boiling mud or water. Extending some distance around the orifice of the dry vents there is usually formed an incrustation of beautiful yellow crystals of sulphur. The bulk of the sulphur, however, lies in the impure clayey mixture distributed over the surface in irregular patches. An average sample of the crust to a depth of about 20 centimeters yielded on analysis 66.1 per cent of free sulphur.
>
> The To-od Pequeño is a continuation of the same solfatara, situated to the south of and at a lower level than the To-od Grande. It exhibits the same phenomena as the upper solfatara, but is much smaller in area. In one portion of the To-od Pequeño is a large cave from the bottom of which issue steam, sulphurous, chlorine, and other gases, corroding the sides and roof of the vault and giving to it a varicolored appearance, due to the secondary minerals formed.
>
> About 1 kilometer southeast of the To-od and separated from it by a high ridge of andesite is another solfatara called the Pangujaan. It is situated on the southern slope of a slide, about 40 meters high and about

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90 meters wide, from the sides of which four or five larger and several more smaller vents give off steam and sulphurous gases in a continuous flow. As at the To-od, these vents are usually ringed with a sublimate of sulphur, close approach to which, however, is very difficult on account of the precipitousness of the slide as well as on account of the heat and obnoxious gases given off. Occasionally the channel leading to one of these vents may become closed, and the flow of gases deflected in another direction, in which event the rich sublimate which has formed in the neck and about the mouth of the vent becomes covered over with a subsequent layer of kaolin, forming a hidden deposit of almost pure sulphur. * * *

The sulphur on Biliran Island, Goodman describes as follows:

On Wednesday, November 22, I left Naval for the interior of the island. The first 6 or 8 kilometers led over a wide trail and an easy grade, turning into a very crooked, steep, and slippery one as the trail entered the forest on the slope of Mount Capiñajan. About 5 kilometers southwest of Capiñajan is situated Mount Guirón upon the slopes of which are located the two most important solfataras on the island of Biliran. The San Antonio, situated on the western slope, at an altitude of about 335 meters, comprises 1 pertenencia, and the Santa Rosalia, situated on the eastern slope, about 185 meters higher than the San Antonio, comprises 2 pertenencias. Both these concessions were granted to Prudencio Ruiz, about the year 1880. During his lifetime, Señor Ruiz spent considerable money in the development of his two concessions, mainly in the construction of roads and pack trails between the solfataras and the towns of Naval and Caibiran, situated respectively on the west and east coast of the Island of Biliran. Another trail passed over Mount Guirón between the two solfataras, making the connecting link in a direct route between Naval and Caibiran. Although for the most part still well defined and easily passable, portions of the trail have become so overgrown that this route across the island has fallen into general disuse. Señor Ruiz died in the early eighties, and the sulphur mines have been abandoned ever since.

The San Antonio solfatara, in its general aspect, is very similar to the To-od south of Burauen, but on a smaller scale, possessing an open expanse of only about 76 by 107 meters or about one-fifth that of the To-od. Its surface is pierced by numerous vents, some of them as large as 3 meters in diameter, presenting the same phenomena as are exhibited in the To-od. The highest temperature recorded in the examination of several wet holes was 99° C. which is the boiling point of water at this altitude. The hot gases emitted from the dry holes made it impossible to approach them close enough to observe their temperature with an ordinary thermometer.

The Santa Rosalia solfatara is situated at the head of the Mapulá River, which flows eastward and empties into the Caibiran River near the town of Caibiran. It differs from the San Antonio and the To-od solfataras in that it does not lie upon a barren and comparatively level flat, but covers both sides and bottom of a low steep ridge and gully. It differs also in that it is no longer active, though apparently but recently extinguished. The Mapulá which flows about 75 meters below the solfatara is so highly mineralized as to be unfit to drink, and its temperature in the neighborhood of the solfatara is about 35° C. With the exception of the Guizo, it is also the poorest of all the solfataras visited in Leyte, both in quantity and in quality of the sulphur ore. That this condition may be due to previous exploitation is likely.

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To make a close estimate of the amount of sulphur available in any of the solfataras mentioned is impossible, on account of the irregularity of the deposit not only superficially but probably in depth as well. From such data as I obtained from a superficial examination alone, it is estimated that about 3,000 tons of sulphur are in sight at the To-od and Pangujaan solfataras south of Burauen, while at the San Antonio, on the Island of Biliran, the estimated amount is about 400 tons. The sulphur in sight at the Santa Rosalia is inappreciable in amount.

Of the sulphur in sight there must be deducted at least 25 per cent for losses in mining and treatment of the sulphur ore, which leaves about 2,250 tons obtainable at the Burauen solfataras and only about 300 tons at the San Antonio. * * *

Goodman considers the exploitation of the Burauen solfataras commercially impossible because of the lack of transportation facilities from the deposit to the coast. If the provincial road were improved over the 42 kilometers between Burauen and Tacloban, the sulphur could apparently be put on the market in Manila at a cost that would permit of a reasonable profit at prevailing prices.

Goodman makes the following cost estimates for the Biliran deposits:

In the case of the San Antonio solfataras on the Island of Biliran, the cost of transporting the refined sulphur to Manila would not be nearly as great as it would be from the Burauen solfataras. The cost of transportation, including the cost of packing on ponies from the solfataras to Naval, putting aboard the boat at Naval and freight from Naval to Manila would be about 37 pesos per short ton.

Owing to the small amount of available sulphur, the process of extraction adopted would have to be one requiring the least expenditure for plant and naturally therefore the least economical in extraction. The construction of calcarone, 8 meters in diameter and 2 meters deep, would cost about 400 pesos, but the loss in treatment would scarcely be less than 33 per cent, leaving of the estimated 400 tons of sulphur in sight only 267 tons of refined sulphur available. It is estimated that the cost of stripping, transportation to calcarone, charging, and smelting would amount to about 3.37 pesos per ton of sulphur produced, or about 900 pesos for the entire amount available. This sum would pay for the hire of one foreman at 3 pesos and six laborers at 75 centavos per day, working for four months, which time would be sufficient if operations were kept up continuously to extract the entire estimated quantity of available sulphur.

The total investment would then be approximately as follows:

	Pesos.
Construction of calcarones	400.00
Stripping and smelting	900.00
Transportation of refined sulphur to Manila	9,879.00
Working tools, repairs to trails, etc	600.00
Total	11,779.00
Total value of the product at the rate of 50 pesos per ton	13,350.00

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According to the above estimate, therefore, the San Antonio solfatara could be exploited at a profit of 1,671 pesos, a margin of profit probably too small to interest anyone but a small investor.

CAMIGUIN ISLAND (NORTHERN).

According to the following extract from a report by Ferguson, transportation is likewise the chief difficulty in connection with the Camiguin Island sulphur.

The principal feature of the economic geology of Camiguin is its solfatara on the west flank of the mountain about 2 kilometers from the sea. This is between 600 and 800 meters in length and perhaps 100 meters wide, following a dry stream bed. The sulphur is very fine and while of course the depth of the deposit is unknown there seems to be a considerable amount of it. The stream vents are not very numerous and there is no troublesome flow of hot water. A solfatara which had been worked commercially in Iceland had a smaller surface area of sulphur, less favorable topography and no local fuel supply. A stream of scalding water had to be diverted before operations could be begun, work could only be carried on during a part of the year, and the sulphur, not as pure as the Camiguin sulphur, had to be carried by ponies a three-days' journey over rough mountain trails to the point of shipment and all supplies carried in the same way. It was this last item which caused the abandonment of the Icelandic sulphur. If test pits should show the Camiguin deposit large enough to warrant development, there is abundant wood-fuel at hand and the sulphur could be purified before shipment. It would only be necessary to pack the sulphur about two kilometers to the beach where it could be sent by native boat to Aparri and there transshipped (or purified there, as there is an undeveloped coal deposit not far up the Cagayan River) or else it could be carried in small boats to Porto San Pio V where steamers might call. The chief problem would be labor, as it is doubtful if the natives of northern Luzon or the Batanes could be induced to work on Camaguin Island. The isolated situation and the long stormy season are also drawbacks.

Analysis of an average sample of this sulphur for percentage of sulphur and the two impurities which can not be freed, arsenic and selenium, made by Reibling of this bureau, gave the following results:

Sulphur	81.6 per cent.
Arsenic	Trace only.
Selenium	None.

I am informed that on the east flank of the mountain there is another even larger solfatara, but I was not able to visit it.

The sulphur of Camiguin deserves investigation. Test pits should be sunk to bed rock to ascertain the depth of the deposit in the known solfataras and the region around the volcano should be thoroughly explored in the hope of discovering new deposits. Native information can not be depended upon as the natives have a superstitious dread of the mountain and it is only with great difficulty that they can be induced to go there.

* * *

POCDOL MOUNTAINS, SORSOGON.

Sulphur claims have been staked on a solfatara well toward the summit on the south side of the Pocdol Mountains, which

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form the boundary line between Albay and Sorsogon Provinces in southeastern Luzon. Samples taken from the surface show sulphur and sulphates impregnating a kaolinic rock. The sulphur content is 46 per cent according to the claim locators, and the surface extent of the solfatara is several hectares. The deposit is convenient to the port of Sorsogon and apparently merits investigation.

IFUGAO SULPHUR.

This deposit is situated on the slope of a slide near Tukukan toward Buguias. Cox, from the Bureau of Science, has been to the locality and reports that a number of vents give off sulphurous gases from which sulphur condenses in small amounts. The whole slide, which consists of from 1,000 to 2,000 square meters, is covered with pumice, more or less impregnated with sulphur. Some of the vents are protected with caps of pumice from under which the gases escape. From underneath these one can usually collect beautiful yellow crystals of practically pure sulphur, samples of which were brought to Manila. This probably has no export value because of the high cost of transportation, but it could be used locally for disinfecting purposes.

MOUNT APO.

I visited this locality in 1908, and found above the 1,400-meter elevation half a dozen or more fair-sized gas-vents about which had accumulated small mounds of nearly pure sulphur. Probably there are between 500 and 1,000 tons in sight on the mountain, and probably much more permeating the rocks. However, the deposits are not very accessible, as it is a difficult matter to climb Mount Apo, about two full days being required to get from the coast to the sulfataras.

TAAL VOLCANO.

There are some small sulphur deposits inside the crater of Taal, but probably not extensive enough for commercial purposes. I have heard this locality mentioned several times as having a great deal of sulphur; most of the yellow stains on the rocks about Taal crater are not sulphur stains, but are due to a large amount of iron salts.

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PORTLAND CEMENT MANUFACTURE IN THE PHILIPPINE ISLANDS.

By WALLACE E. PRATT.

The general interest in the possibility of the manufacture of Portland cement in the Philippines, as shown by the reported organization in Manila of a company for the purpose of cement manufacture, has led to the publication of this report of observations made during a recent study of the most promising localities containing possible raw materials. Cox [1] has already published two articles on cement materials dealing with the chemical character of a number of typical shales and limestones and his data have been referred to and drawn upon freely in this paper.

CONCERNING AVAILABLE MARKETS.

Before discussing the local conditions which would govern the location and operation of a cement mill in the Philippine Islands, it is important first to consider the possible market for the output of such a plant. To one acquainted with the cement market of the countries adjacent to the Philippine Islands it is apparent that a local company would be unwise to rely upon successful competition in any other than the Philippine market. Japan, China, Hongkong, and French and British East India all have cement plants with established markets and the further advantage of cheaper fuel and cheaper labor than can be had at present in the Philippines. Therefore, the local consumption is a consideration of primary importance.

During the calendar year 1911, the Philippine Islands imported 382,700 barrels of Portland cement, according to the records of the Insular Collector of Customs. The following table based on the Annual Reports of the Insular Collector of Customs shows the quantities of cement imported during each fiscal year since 1907, the invoice value of the cement, and the countries from which the importations came.

[1] Philippine Raw Cement Materials. *Phil. Journ. Sci., Sec. A* (1909), 4, 211.

Volcanic Tuff as a Construction and Cement Material. *Ibid.* (1908), 3, 391.

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TABLE I.—*Quantity, origin, and average cost, exclusive of import duty on board ship at destination, of all cements imported into the Philippine Islands from July 1, 1906, to June 30, 1911.*

Imports from—	Fiscal year 1907.		Fiscal year 1908.		Fiscal year 1909.		Fiscal year 1910.		Fiscal year 1911.	
	Barrels.[a]	Costs[b]	Barrels.[a]	Costs[b]	Barrels.[a]	Costs[b]	Barrels.[a]	Costs[b]	Barrels.[a]	Costs[b]
United States					215	2.56	50,600	4.72	38,250	4.80
United Kingdom			375	6.50	7,670	3.33	518	3.03	4,030	3.89
Germany			11,120	4.58	13,375	4.05	15,230	3.79	8,670	3.90
France			448	3.90	100	3.40	135	3.73	10	2.28
Italy			1	4.00						
Belgium			8,450	2.98	5,920	1.79	2,920	2.03	2,150	2.00
Netherlands					500	2.06				
Russia			812	5.19	2,310	5.18	730	5.20	522	3.91
British East India					320	4.41	15	4.80	9	4.22
French East India							37,500	3.17	69,600	3.38
Hongkong			135,000	4.28	107,100	3.57	128,300	3.29	212,400	3.32
Japan			50	2.76	1,750	3.27	1,970	4.02	3,192	4.00
Austria-Hungary									30	4.48
Spain							90	3.78		
China							2,640	3.15	1,612	3.38
Total	[c] 107,000		156,256		139,260		240,648		340,475	
Average cost		5.50		4.24		3.55		3.46		3.51
Special entries[d]			116,000		110,500		25,730		28,950	
Grand total	107,000		272,256		249,760		266,378		369,425	

[a] Barrels of 400 pounds (181 kilograms), gross weight.
[b] Invoice cost in pesos, Philippine currency, per barrel.
[c] Approximate.
[d] Free entries for Manila Railway, Philippine Railway, and United States and Insular Governments.

The import duty of 32 centavos per 100 kilograms gross weight (about 59 centavos per barrel), landing charges, and importers' profit make the local market price from 4.50 to 5.50 pesos per barrel. Cement from the United States enters duty free, but the long transportation necessary to put it on the Philippine market has kept down the importation of American cement.

The present consumption of Portland cement would not justify the erection of a plant of greater daily capacity than 1,000 to 1,500 barrels. Although the consumption will presumably continue to increase, it is probable that the average unit value of the cement will be lowered, especially in the event of competition from within the Islands. A plant in the Philippines must be able to manufacture at a cost well below the present market prices if it is to succeed financially.

CONCERNING THE PROBABLE COST OF CEMENT MANUFACTURE IN THE PHILIPPINES.

Several of the more important factors which enter into the cost of Portland cement will tend to make manufacture in the Philippines, under the existing conditions, an expensive operation. At the present market price of coal, for instance, fuel for power and for kilns in a local mill would cost 1.00 to 1.50

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pesos per barrel of finished cement. The corresponding figure for small mills in average American practice is 45 centavos to 50 centavos. The stringent specifications in force in the Philippines require a superior, hard burned, finely ground cement. The manufacture of such a cement is relatively expensive. Labor in the Philippines is more expensive than in the adjacent countries where most of the competition would arise. Gypsum for retarder must be imported, and, while a small item in itself, it would add to the expense of manufacture.

Barrels for packing cement could probably be manufactured in the Philippines. Dr. F. W. Foxworthy of the Bureau of Forestry has suggested that some of the various grades of *lauan* could be used as a wood for slack cooperage. Judging from past experience, it would not be feasible to pack in bags cement intended for use in the Philippines. In spite of the possibility of their local manufacture, barrels for packing will probably be expensive.

In the face of these necessarily high costs, it is imperative that other items of expense be made lower than normal if cement is to be manufactured at an average cost. Quarrying, grinding, mixing, transportation, and marketing must be accomplished at a minimum cost. The physical and chemical characters of raw materials and the location of the mill with respect to markets and raw materials are consequently of more than usual importance. A favorable site under the circumstances would entail harbor or railroad facilities (or both), located centrally with respect to the general market, and soft, naturally blended raw materials adjacent to the mill itself. If in addition to these favorable features a cement company has access to one of the fields of the better grades of Philippine coal so that by developing the coal it could reduce fuel costs, the prospect would apparently be favorable.

The importance of the conditions which have been suggested in their application to the Philippine field, will be brought out in the discussions of several of the localities which have been considered in connection with cement manufacture.

An estimate of the probable cost of local manufacture of Portland cement is inserted at this point (Table II) for consideration with the market prices just quoted. The estimates are liberal and the costs submitted could probably be reduced once the manufacture and market were thoroughly established. These estimates are based on reliable figures [2] for costs at small mills in

[2] Eckel, Edwin C., Cements, Limes and Plasters (1909), 554.

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average American practice. They are intended to apply to manufacture at the most favorable of the possible Philippine locations described later in this report, and assume the following conditions: (1) A modern dry process mill of 1,000 barrels daily capacity, costing between 800,000 and 1,100,000 pesos; a mill site with harbor facilities, located centrally as to markets, and adjacent to one of the better fields of Philippine coal; (2) an abundant supply of uniform raw materials partly blended by nature, of desirable chemical and physical character, soft and dry so as to be cheaply quarried, and available at the mill site without transportation; gypsum for retarder to be imported; (3) two estimates, one assuming the use of superior local coal at 5 pesos per ton, and one assuming the use of Australian or Japanese coal at 10 pesos per ton; (4) sufficient native labor at 60 to 80 centavos per day per man; (5) supplies 25 per cent to 30 per cent higher than in average American practice; (6) office and laboratory expense, about 25 per cent higher than in average American practice; administration and sales expense, 20 per cent higher than in average American practice; (8) interest, depreciation, sinking fund, etc., about 30 per cent higher than in average American practice. The cost of barrels for packing is not included in the tabulated estimates. The fuel items allow 110 kilograms of Australian coal, or 160 kilograms of Philippine coal per barrel of finished cement. The high estimated costs for skilled men, administration, interest, depreciation, etc., are believed to be justified by the local conditions.

TABLE II.—*Cost of manufacture in pesos, Philippine currency, per barrel of cement (172 kilograms net).*

Items.	Cost.	Items.	Cost.
	Pesos.		*Pesos.*
Raw materials (cement rock and clay)	0.11	Administration and sales	0.20
Gypsum (retarder)	0.04	Interest on cost of plant	0.21
Fuel:		Depreciation and sinking fund	0.24
Philippine coal	0.80		
Australian or Japanese coal	1.10	Total using Philippine coal	2.36
Labor	0.24	Total using Japanese or Australian coal	2.66
Supplies	0.39		
Office and laboratory	0.13		

Barrels for packing would probably cost at least 60 centavos each, so that the margin between the average cost in 1911 (including duty) to the importer and the estimated cost of local manufacture, plus the cost of barrels for packing, would be 84 centavos or 1.14 pesos per barrel depending on the fuel used in the Philippine plant. This margin must cover freight charges on cement to market and manufacturer's profit.

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RAW MATERIALS.

The available materials which are more or less suitable for use in the manufacture of Portland cement are widely distributed. The calcareous materials include pure, hard limestones, argillaceous limestones, and marl or chalk. The argillaceous materials include shales, residual and transported clays, volcanic tuff, and a siliceous material of less general occurrence which is referred to in this report as gray-wacke.

CALCAREOUS MATERIALS.

The most generally distributed calcareous material is a limestone of Miocene age which is usually associated with shales and sandstones and occurs abundantly on nearly every one of the larger islands. This massive limestone is often of coralline origin but is always hard and crystalline, approaching marble in character. It has been subjected to strong metamorphic influence and is found usually in mountainous districts. Dr. A. J. Cox has analyzed a number of samples of this limestone from different localities and has shown it to be constant in composition and singularly pure. Analyses 1, 2, and 3 in Table III are representative.

Coralline limestone of Pleistocene or Pliocene age occurs abundantly, especially throughout the Visayan Islands. At many places this material occurs as raised portions of reefs which are still growing in the adjacent seas. Usually this coral formation is a moderately soft, rather pure limestone which retains almost perfectly its original coralline structure. The composition of such material is partially shown in analyses 4 and 5, Table III. Typical coralline material is also found, alternating with beds of marl. Analysis 15, Table III, is from a 3-meter bed of marl occurring in a coralline limestone series at Argao, Cebu. At other places the growth of the corals has apparently been locally irregular, and only traces of coral are encountered. Rounded and angular fragments of coral with marine shells, in a matrix of soft, clayey marl, make up terraces which are very extensively developed along the present coast lines of some of the coralline islands. These terraces appear to be marginal formations and grade imperceptibly into the older, higher reefs farther inland. At Naga, Cebu, this coralliferous marl (as it may be designated) covers several square kilometers in a terrace 30 to 50 meters high and borders coralline limestone which rises to an elevation of more than 350 meters. The composition of the Naga material is shown in analyses 6 to 14 inclusive, Table III. It approaches closely a typical raw cement mixture in composition and would readily be classed as a cement rock.

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Sampling (by drilling) and analysis have shown uniform material in quantities sufficient to supply cement rock for 30,000,000 barrels of cement. The silica-alumina ratio is high and there is a large proportion of iron to alumina, characteristics generally thought to be desirable in cements for construction in sea water.

Another class of marl has been noted at several places, but has been studied only in Zambales and Pangasinan Provinces. This marl is usually thin bedded and occurs in a sedimentary series. It is soft, fine-grained, and similar in composition to the Cebu marls.

An argillaceous limestone is exposed in the bed of the Danao River near the Camansi Mine, in Cebu, and a similar limestone occurs east of Angat in Bulacan Province. These limestones are hard and fine grained. The Cebu exposure shows a blue to gray, bedded limestone, apparently in conformable stratification with the Miocene coal-bearing series. Smith [3] mapped this formation and found it to be of considerable extent. It

TABLE III.—*Analyses of calcareous raw materials for cement.*

Sample No.	Silica (SiO_2).	Alumina (Al_2O_3).	Iron oxide (Fe_2O_3).	Lime (CaO).	Magnesia (MgO).	Alkalies (Na_2O K_2O).	Loss on ignition.	SiO_2. Al_2O_3 · Fe_2O_3.
1[a]	0.36	0.18		55.62	0.00		43.93	
2[a]	0.10	0.17		55.23	0.45		43.80	
3[a]	0.97	0.56	0.36	53.86	0.19		43.18	
4[b]	1.31	3.90		52.01	0.63			
5[b]	2.61	2.23		52.85	0.88			
6[b]	6.28	4.33		45.76	2.70			
7[b]	11.12	4.28		45.65				2.6
8[b]	14.10	5.77		43.27				2.4
9[b]	11.57	4.62		46.25				2.5
10[b]	12.62	5.75		43.36				2.2
11[c]	9.43	4.02		47.53				2.3
12[c]	10.28	0.63	3.28	45.96				2.9
13[c]	8.37	0.22	3.25	49.84	1.02			2.4
14[c]	11.99	0.57	2.90	45.69				3.5
15[b]	8.93	6.45		44.35	2.70			1.4
16[a]	29.00	11.38	5.35	26.25	0.65	1.98	23.00	1.7
17[a]	24.02	7.49	2.00	33.88	2.12		28.25	2.5

[a] Cox, Alvin J., Philippine Raw Cement Materials, *Phil. Journ. Sci., Sec. A* (1909), **4**, 211.
[b] Analyzed by Forrest B. Beyer, Bureau of Science.
[c] Analyzed by T. Dar Juan, Bureau of Science.

1. Miocene limestone from Mount Licos near Camansi Coal Mine, Danao, Cebu.
2. Miocene limestone (Marble) Romblon, Capiz.
3. Miocene limestone Batan, Albay.
4. Coralline limestone (Pliocene) Cebu, Cebu.
5. Coralline limestone (Pliocene) Danao, Cebu.
6. Coralline limestone (Pliocene) Guimaras Island.
7–14. Coralline marl (Pliocene) Naga, Cebu. Analyses typical of a series of test hole samples representative of a thickness of about 15 to 30 meters over an area of about 15 hectares.
15. Bedded marl or chalk (Pliocene) Argao, Cebu.
16, 17. Argillaceous limestone (Miocene) from near Camansi Coal Mine, Danao, Cebu.

[3] The Geology of the Compostela-Danao Coal Field. *Phil. Journ. Sci., Sec. A* (1907), **2**, 377.

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lies about 10 kilometers inland from Danao. The chemical composition of this material is shown by analyses 16 and 17, Table III.

Table III shows the relative proportions of the essential constituents of the calcareous materials. In addition it may be stated that magnesia, alkalies, and sulphur trioxide are rarely abundant enough to demand consideration.

ARGILLACEOUS MATERIALS.

Shales make up the greater part of the series of sedimentary rocks with which coal is associated in the Philippines and are to be found very generally over the Islands. They are typically thin-bedded and of nonuniform chemical and physical character.

Ordinarily the beds carry a considerable proportion of sand composed mainly of feldspathic and ferromagnesian grains, but locally the sand content is lacking and the material is very fine-grained. Sandy and fine-grained shales often occur alternately in very thin strata. The shales are generally folded, or tilted from their normal horizontal position, so that to follow any particular bed would ultimately involve a mining operation in many localities. In Table IV are partial analyses of a number of shales from different parts of the Archipelago. The striking feature of these analyses is the uniformly low silica-alumina ratio. Since it is a general statement that the alumina plus the iron oxide in a desirable raw mixture should amount to less than half of the total percentage of silica, and the best recent practice is tending toward an even higher silica-alumina ratio, it would be inadvisable to attempt to use these low silica shales with the pure limestone which is commonly most available for combination with them.

From the analyses which have been performed on Philippine shales and a study of these materials in the field, it is concluded that the low silica content is a general characteristic except when the material is very sandy or where the composition has been modified by metamorphic influences. A general low silica content in these shales could be explained on the assumption that the former land area from which they were derived was made up largely of basic igneous rocks similar in composition to those which occur abundantly in the older portions of the present island masses. The possibility of a low silica content in the shales as a general feature is important in this connection since it tends to make the pure limestones occurring in many of the coal fields less available for use as a cement material.

The residual and transported clays in the Philippines are all of recent age and result from the disintegration of rock in place

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on the present land surface and erosion by modern drainage systems, respectively. With both types of clay the physical and chemical properties vary greatly, depending on the character of the parent material. The low silica-alumina ratio which is shown by the shales is found very often in the clays, and generally neither type of clay is uniformly fine-grained. The residual clays contain fragments of partially disintegrated rock, while the transported clays, having been deposited generally by short rivers whose flow and consequent sediment-carrying capacity varies greatly and rapidly, consist of irregularly-sized particles. The compositions of residual and transported clay appear in analyses 10 to 14 inclusive, Table IV.

The andesitic tuff, which occurs in the vicinity of Manila and throughout southwestern Luzon, has been shown by Cox [4] to contain a proper silica-alumina ratio for a Portland cement mixture. Chemically it is quite suitable for combination with a pure limestone, but in its physical character the tuff presents some undesirable features. It is a fragmental material laid down in recent geologic times and frequently contains a considerable proportion of scoria, pumice, angular pieces of rock, etc. At a number of places where it has been observed, it would apparently be a rather difficult matter to obtain a sufficiently uniform quarry product. Clays which result from the erosion of this tuff are low in silica. Analysis 16, Table IV, is representative of the volcanic tuff in the vicinity of Manila.

The siliceous raw cement materials available in the Philippines include schists, gray-wackes, and a fine grained siliceous rock which is probably a rhyolite.[5] The schist is usually quartzose, a quality which with its tough, scaly structure would make it difficult to grind and burn. The known schists are too siliceous to be used except in very small proportions.

The gray-wackes occur in the cordilleras of several of the islands, but are best known on the Island of Cebu where they flank an andesitic rock which forms the core of a comparatively high ridge along the southeast coast. The rhyolite occurs in Cebu associated with other igneous rocks in the cordilleran regions. Both the rhyolite and the gray-wacke are very fine-grained, gray to white, and moderately hard. The gray-wacke is made up mainly of fragments of plagioclase feldspar crystals, in a cement which is probably silica. Either of the materials is suited physically for use as a raw cement material. Their chemical compositions are shown in analyses 18 to 21 inclusive, Table IV.

[4] *Loc. cit.*

[5] *Phil. Journ. Sci., Sec. A* (1907), 2, 407.

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Summarizing briefly the discussion of the available raw materials, it appears that the Miocene limestone, which is most widely distributed, loses importance as a cement material because of the general lack of an argillaceous base sufficiently siliceous to be used with it, and because the limestone is usually found in the mountainous districts where transportation is difficult. The coralliferous marls on the other hand are important because of their chemical composition, their abundance, physical character, and their occurrence along sea coasts where transportation is more feasible. Nearly all the raw materials show remarkably low magnesia content and no other chemically objectionable elements.

TABLE IV.—*Analysis of argillaceous raw material for Portland cement.*

Sample No.	Silica (SiO_2).	Alumina (Al_2O_3).	Iron oxide (Fe_2O_3).	Lime (CaO).	Magnesia (MgO).	Alkalies ($Na_2O \cdot K_2O$).	Loss on ignition.	SiO_2. $Al_2O_3 + Fe_2O_3$
1[a]	35.02	13.98	6.01	17.44	2.84	1.97	17.50	1.8
2[b]	52.84	28.50		1.98	1.82	3.10	.....	1.9
3[b]	46.31	28.68		.....	.....	.....	.....	1.6
4[b]	51.88	26.13		.....	.....	.....	.....	2.0
5[b]	55.97	30.09		.....	.....	.....	.....	1.9
6[a]	53.25	24.11	9.03	0.80	2.22	.....	8.72	1.6
7[d]	33.74	16.48		.....	.....	.....	.....	2.0
8[d]	37.84	21.07		.....	.....	.....	.....	1.8
9[d]	49.08	27.23		.....	.....	.....	.....	1.8
10[e]	47.77	18.73[c]	7.19	1.78	2.06	1.86	13.84	1.8
11[e]	50.81	20.54	7.37	0.91	1.05	.....	8.14	1.8
12[e]	52.83	21.01[c]	8.40	4.04	2.58	2.68	9.08	1.8
13[a]	60.17	22.65	4.66	0.31	1.85	.....	6.35	2.2
14	60.50	26.50		2.00	.....	.....	8.45	2.3
15[d]	37.13	20.04		.....	.....	.....	.....	1.9
16[f]	59.27	17.06	5.06	3.37	1.52	6.12	6.42	2.7
17[a]	80.12	12.56	1.15	0.12	0.48	3.69	1.94	5.8
18[b]	68.10	14.50	2.70	3.07	0.94	.....	.....	4.0
19[b]	66.14	12.75	0.96	3.43	0.53	.....	.....	4.8
20[b]	69.16	14.06		.....	.....	.....	.....	4.9
21[g]	76.15	14.93	0.27	1.40	1.24	5.65	.....	5.0

[a] Cox, Philippine Raw Cement Materials, *loc. cit.*
[b] Analyzed by Dar Juan.
[c] Includes titanium oxide (TiO_2).
[d] Analyzed by Beyer.
[e] Cox, *Phil. Journ. Sci., Sec. A* (1907), **2**, 413.
[f] Cox, Volcanic Tuff as a Construction and a Cement Material, *loc. cit.*
[g] Ferguson, *loc. cit.*

1. Shale from Batan Island.
2–5. Shale from Batan Island. Samples from drilled test holes.
6. Shale from near Camansi Coal Mine, Danao, Cebu.
7. Shale from near Camansi Coal Mine, Danao, Cebu.
8. Shale from Tigbauan, Iloilo.
9. Shale from Cataingan, Masbate.
10. Alluvial Clay from Malinta, Bulacan.
11. Clay from Binangonan, Rizal.
12. Alluvial Clay from Pasig River near Manila.
13. Clay from near Camansi Coal Mine, Danao, Cebu.
14. Alluvial Clay from Pandan River, Naga, Cebu. Representative of drilled test hole samples.
15. Alluvial clay from Mangrove Swamp Loay Bohol. Sample from drilled hole.
16. Volcanic Tuff. From vicinity of Manila.
17. Schist from Romblon.
18–20. Gray-wacke, Naga, Cebu. Typical of a series of samples from drilled test holes over an area of 16 hectares.
21. Rhyolite from Cebu.

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CONCERNING POSSIBLE MANUFACTURING CENTERS.

Other things being equal, market and transportation considerations would make Manila, the chief supply and distributing point for the Islands, or one of the secondary but more centrally located ports, such as Cebu or Iloilo, the most feasible site for a local cement plant. If any of these central localities possesses suitable raw materials, then a location away from the main lines of commerce and distant from the geographical and commercial center of the Archipelago would be considered only in case it offered unusual advantage in the excellence of raw materials, harbor facilities, or more particularly, if it gave reasonable promise of a local supply of suitable fuel.

Localities, each of which present in some degree the characteristics essential to a cement manufacturing site, are to be discussed briefly. Their relative situation is shown on the mineral locality map on page 9.

1. Island of Cebu.
2. Vicinity of Manila.
3. Island of Batan, Albay Province.
4. Island of Masbate, Sorsogon Province.
5. Island of Polillo, Tayabas Province.
6. Vicinity of Bani, Pangasinan Province.
7. Island of Romblon, Capiz Province.
8. Vicinity of Balayan, Batangas Province.
9. Vicinity of Iloilo, Iloilo Province.
10. Vicinity of Loay, Bohol Province.

There are other localities several of which are probably as worthy of description as some that have been included in the foregoing list, but, as far as is known, they are not important possible locations. The above localities will be considered briefly in reverse order.

Vicinity of Loay, Bohol.—The town of Loay, Bohol, is considered chiefly because in combination with possible materials and a central location (with respect to the island group) it offers natural water power facilities. Rough estimates show that the Loay River would afford power for a cement mill of moderate capacity. Water power should reduce the fuel consumption of a plant by 30 to 40 per cent and is thus a considerable asset. The town is located on the Pliocene coral formation, which at this point is too pure to be used alone for a cement raw mixture and no suitable clay or argillaceous material is available for combination with it. Labor conditions would probably not be satisfactory and there is no coal closer than the Cebu field.

Vicinity of Iloilo, Iloilo.—The harbor at Iloilo is the principal advantage of this proposed location. The Island of Guimaras lying just outside the port of Iloilo consists largely of raised coral

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reefs. These have shown some irregularity in composition, with an unusually large proportion of magnesia (analysis 6, Table III). No argillaceous material is available on Guimaras Island, and the adjacent mainland of Panay affords only a low-silica alluvial clay. The magnesia content of the limestone is not prohibitive and the material carries more or less silica, alumina, and iron oxide. Further testing might show limestone with a silica-alumina ratio which make it suitable to be used with the clay at Iloilo. Iloilo Province has no important coal resources.

Vicinity of Balayan, Batangas.—At Balayan in the southwestern part of Batangas Province, coralline limestone, probably of the Miocene type, is found adjacent to volcanic tuff. There is no suitable harbor near Balayan and no coal is known in Batangas Province. The materials are similar to those in the vicinity of Manila, and since Manila offers a number of other advantages that are lacking at Balayan, this place needs no further consideration at the present time.

Romblon, Capiz Province.—Romblon occupies a position near the geographical center of the Archipelago and has an excellent harbor. Several years ago preliminary steps were taken toward manufacturing Portland cement at Romblon. The prospectus of the company which was organized states that the marble and schist which occur near the harbor at Romblon were to be used as raw materials. The analyses of these two materials appear in Tables III and IV, and their undesirability from a chemical standpoint is at once evident. The high silica content which would necessarily result from such a mixture would cause difficulty in burning. The schist, moreover, is unfitted by its physical nature for use as a cement material. Romblon would be obliged to depend on the general market for coal.

Bani, Pangasinan Province.—Fanning [6] found unusually desirable cement materials near Bani, in northwestern Pangasinan. He describes marls and shales with very satisfactory chemical and physical properties, in quantities and relations suitable for quarrying. The raw materials are at a distance of about 30 kilometers from Sual, Pangasinan, where harbor facilities are available. No coal of economic importance occurs in the district.

Island of Polillo, Tayabas Province.[7]—On Polillo Island off the east coast of Luzon is a coal field which contains an excellent sub-bituminous coal. With the coal are associated shales, sandstones, and limestones. While it is probable that these shales

[6] Geological Reconnaissance of Northern Pangasinan Province. *Phil. Journ. Sci., Sec. A* (1912), 7.

[7] Smith, Coal Resources of the Philippine Islands. *Min. Resources P. I. for 1910, Bur. Sci., Div. Min.* (1911), 37.

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and limestones are similar to those in other coal districts, their character and relations are not definitely known. Polillo is far removed from commercial communication and is but sparsely populated. Marketing and labor costs would be high. The chief asset the island possesses as a possible cement manufacturing center is its undeveloped coal.

Masbate, Sorsogon Province.—The following information concerning Masbate is taken from unpublished notes of Mr. H. G. Ferguson on the Cataingan coal field. Near Cataingan Bay on the Island of Masbate, there is an undeveloped field of subbituminous coal. The seams occur in the usual series of Miocene shales and limestones. The low silica-alumina ratio of a typical Masbate shale is shown in analysis 9, Table IV. Such a shale could not be used satisfactorily with the pure limestone, which has been observed in the Cataingan district. The character of the raw materials at this location is a difficulty which could probably be overcome at an increased cost of production by using a small proportion of sandstone in the mix. Masbate is centrally located and Cataingan Bay offers harbor possibilities. The coal is of a quality which should make it a satisfactory fuel.

Island of Batan, Albay Province.—On Batan Island is the best developed coal mine in the Philippines. The coal at this mine is of rather low calorific value, however, and it is questionable if it could be used satisfactorily to burn cement. The shales associated with it are uniformly too low in silica to be used with the only limestone available, which is the pure crystalline type shown in analysis 3, Table III. The silica content could be brought up to standard, perhaps, by using a small proportion of the quartz-sandstone grits which occur irregularly in the coal-bearing series. On Batan Island, owing to the dip of the strata, it would probably become necessary to mine the shale in order to follow any bed or succession of beds. The location of the island, with respect to the market for cement, is rather unfavorable.

Vicinity of Manila.—The only calcareous raw materials in the vicinity of Manila are two exposures of Miocene limestone, one of which is near Montalban and the other in a semimountainous country, about 7 kilometers north of Binangonan, Rizal Province. Both of these are hard, crystalline limestones which chemically are almost pure calcium carbonate. Montalban is about 30 kilometers distant from Manila, over a branch line of the Manila Railroad. Binangonan is about 20 kilometers from Manila, and between the two, water communication *via* the Pasig River and Laguna de Bay is feasible for launches and scows.

At Montalban alluvial clay of the usual character is available. Shales occur with the limestone, but they are very irregular and

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not in relations suitable for quarrying. At Binangonan clays similar to those at Montalban occur (see analysis 11, Table IV). The volcanic tuff which, as has appeared, is more satisfactory chemically for use with this class of limestone than the common clays borders the Pasig River between Manila and Laguna de Bay and stands up in bluffs that could be easily quarried. No coal occurs in this district, but imported coals could be obtained direct from the Manila market where they are cheaper than at smaller ports.

The factor of water transportation makes the Binangonan limestone more available to Manila than that at Montalban. The expense of railroad transportation would prohibit the success of an attempt to manufacture cement at Montalban, or to bring the limestone to a plant at Manila. A mill located at Binangonan would be seriously handicapped unless it were able to obtain more siliceous clay than that from Binangonan shown in analysis 11, Table IV.

The most economic scheme for utilizing the materials in the vicinity of Manila (assuming that the physical character of the volcanic tuff is shown to be not seriously objectionable), would be to locate the plant on the Pasig River at Manila adjacent to the volcanic tuff, and to bring the limestone from Binangonan to the mill. This plan would necessitate the transportation of all the limestone for the mix, but would avoid the equally long haul of a probably greater bulk; that is, all supplies, fuel, and finished cement, which would be necessary if the plant were located at Binangonan.

The advantages of the Manila location are all those which accrue from proximity to the main port of the Islands. The disadvantages are: (1) the extra cost of quarrying a very hard limestone; (2) the transportation of this limestone over a distance of 7 kilometers by land and about 17 kilometers by water; (3) the lack of natural protection at Binangonan, where an anchorage must be provided for floating stock, against the severe storms which occasionally sweep Laguna de Bay; and (4) possible added expense in grinding and burning the volcanic tuff raw material.

Island of Cebu.—The city of Cebu is the most central large port in the Islands. The Cebu coal field has been considered by both Spanish and American engineers to be the most promising field in the Philippines. Next to that of Batan Island, it is the best developed field. The Cebu coal is a sub-bituminous variety, and would probably be a satisfactory cement kiln fuel. The following proximate analysis is representative of the Cebu coal.

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Analysis of coal from the Camansi Mine, Danao, Cebu.[8]

Constituent.	Per cent.
Water	9.01
Volatile combustible	43.46
Fixed Carbon	43.18
Ash	4.35
Sulphur	2.40
Calories	6,249

In addition to shales and limestones similar to those associated with coal at other places in the Philippines, Cebu has available cement materials in the coralliferous marls and limestones which flank the main cordillera throughout the length of the island. The analyses and descriptions of these materials have already been given.

The Cebu coal field divides itself into two principal districts, one of which lies about 12 kilometers inland from Danao and the other 15 kilometers inland from Naga. Either of these towns affords rather favorable conditions for cement manufacture. At Danao the coral formation (analysis 5, Table III) or the Mount Licos limestone (analysis 1, Table III) could be used with the argillaceous limestone (analyses 16 and 17, Table III) to produce a suitable cement mixture.

The Mount Licos limestone occurs at an elevation of about 500 meters in a mountainous district, and to utilize it, a plant should be located preferably at the Camansi coal mine which is near by. This location would save any transportation of coal, once the Camansi property was producing, but the plant would be accessible with difficulty. All supplies and all finished cement would come in or go out over a narrow gauge railroad between the plant and Danao, where transshipment would be necessary.

This consideration, together with the fact that the coral on the coast is physically more suitable than the Mount Licos limestone, make it preferable to locate the cement plant at Danao, and to use the coralline limestone there with the argillaceous limestone which could be brought over the railroad from the coal mine. Danao has no natural harbor facilities and is about 30 kilometers by railroad from the port of Cebu.

At Naga a mill could be located so as to be on the Philippine Railway within 20 kilometers of the town of Cebu and at the same time on the water's edge at Tinaan Harbor, an adequate and naturally protected anchorage. (See Chart No. 4458, Coast and Geodetic Survey.) The Uling coal field is accessible from Tinaan through the valley of Pandan River.

[8] Smith, *loc. cit.*

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A mill at this point would have the soft coralliferous marls (analyses 7 to 17 inclusive, Table III) rising immediately behind it in an extensive terrace, 30 to 50 meters high with ideal relations for quarrying. The mill itself would be located on an alluvial clay deposit (analysis 14, Table IV) formed as a flood plain of the Pandan River. This clay is present in abundant quantity. At a distance of 2 kilometers from Tinaan up the Pandan River the gray-wacke (analyses 18 to 20 inclusive, Table IV) occurs in practically unlimited quantity. Calculation shows that the coralliferous marl itself could be used for 90 to 95 per cent of a raw cement mixture, requiring the addition of only 5 to 10 per cent of the alluvial clay or the gray-wacke. Since the required addition is so small a proportion of the mix, the alluvial clay, although less uniform than the gray-wacke, would serve admirably, and because it is adjacent to the millsite it would be preferable to the gray-wacke for this purpose.

The Cebu field offers a central location, harbor facilities, possible local fuel supply and naturally blended raw materials of very satisfactory chemical and physical composition, available at suitable millsites. The raw materials should be cheaply quarried and probably would pulverize readily, although it is not always true that soft materials pulverize easily. Labor in Cebu is more abundant and cheaper than in Manila, but proportionately less efficient, perhaps, so that the two locations are about equally advantageous on this score. There are several large lumbering concerns on the Island of Negros near Cebu, where cement barrels could probably be manufactured from the mill culls with financial advantage both to the lumber companies and the cement mill using the barrels.

CONCLUSION.

From the evidence brought out in the foregoing discussion, it must be concluded that the Island of Cebu affords better conditions for the commercial manufacture of Portland cement than any other known locality in the Philippine Islands. It is evident, further, that Cebu offers unusually favorable conditions for a profitable industry in this field, assuming that the present consumption and market value of cement is maintained. It should be pointed out that in case the further development of the local coal fields proved them to be valueless, Cebu, being an open port, could import coal direct almost as cheaply as Manila could. Although the present consumption of Portland cement centers at Manila, the future progress of the Philippines will in all probability result in the greater relative importance of the southern island markets.

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PHILIPPINE CLAY WORK.

By C. H. Crowe.[1]

The pottery industry in the Philippine Islands is in a primitive state. Clay is not refined nor is any effort made to produce a superior product. Outside of Manila, with few exceptions, no kilns are used and no Filipino has heretofore made glazed ware. In various parts of the Philippine Islands there are good clays for all classes of clay products. There are deposits of fire clay needed in kiln construction and deposits of quartz and felspar for the glazes. It is only necessary to interest the people and to educate young men who will be able to organize small factories and gradually develop the clay-working industry.

In the 1912 Philippine Exposition, 12 provinces exhibited pottery and 10 of these had samples of clays. One province only, Laguna, had glazed ware. This was made in the towns of San Pedro Macati and Pagsanjan. The San Pedro Macati exhibit consisted of glazed flower-pots, fruit stands, pitchers, toys, etc. The body was yellowish and well-fired. The glaze was a lead silica mixture. Several of the pieces were pleasingly colored by the addition of metallic oxides to the glaze.

The Pagsanjan factory is interesting from the fact that it was organized and managed by two boys who studied nine months in the pottery school of the Bureau of Education. They made their own bricks and built the kiln. They refined the clay, composed the glazes, and did all the work. They exhibited flower pots, water jars, pitchers, trays, toys, etc. The bodies of many pieces were red, but some of them were white. No Filipino has heretofore been able to use a white clay in pottery. These boys used a soft lead glaze in yellow, brown, green, and blue. This refining of clay, applying glazes, and firing in kilns marks a step in the advancement of clay work. Before the Bureau of Education instituted a pottery school, nothing but a crude, half-baked, unglazed ware was produced by any Filipino.

[1] Head of the ceramic department, School of Arts and Trades, Manila.

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In June, 1911, the pottery school which had been just established at Santa Cruz, Laguna, was united with the Philippine School of Arts and Trades at Manila and became the ceramic department. The students of the wood-working course constructed the building for this department, and the following equipment was made in the school: a blunger of 120 liters capacity, a settling tank of 120 barrels capacity, 1 kiln (3.7 meters by 7.4 meters) containing 2 ovens, a small test kiln, 11 potter's wheels, a kneading table, a modelling table, drying racks, and a filing case for clay samples and tests. There are also the following power machines: a cup machine, a saucer and plate machine, a lathe, a ball mill, a glaze mill, and a polisher. This equipment will accommodate about 60 pupils and with it terra cotta, faïence, stoneware, porcelain, and all other classes of clay work can be produced.

The ceramic department aims to train boys so that they will be able to build, equip, and operate pottery factories. In this first year of the course the students have constructed the kilns, made tiles, common bricks, fire bricks, and glazed ware of various colors and designs (faïence). Sixteen provinces have submitted samples of clays and from these 100 tests have been made.

Fifteen samples of grayish and white clays (locally called *yeso*) have been received. Of these, 7 burned white; 6, gray; 1, red; and 2, buff. White kaolinic clays from Los Baños, Laguna, and from Nasugbu, Batangas, have proved very satisfactory in certain combinations. Used alone the Los Baños clay warps and cracks under fire treatment owing to its excessive shrinkage, while the Nasugbu clay alone lacks the necessary plasticity for working. Combined in equal proportions, the result is a very refractory material which burns almost white and shows but little shrinkage. Mixed with less refractory clays, they might be used for paving brick, since they tend to increase the range of vitrification. Further experiments with the white burning clays will be made for stoneware and porcelain.

Twenty-nine clays and mixtures have been tested for vitrified brick. Of these, 3 were slightly warped, 5 cracked, 1 swelled, 15 showed a range too short between vitrification and viscosity, and 5 with a slight variation of mixture would apparently make a good commercial brick.

The most successful experiments have been made on refractory ware. Fire bricks, fire-clay tiles, and posts have been used in the kiln and have in every way served as well as the imported product.

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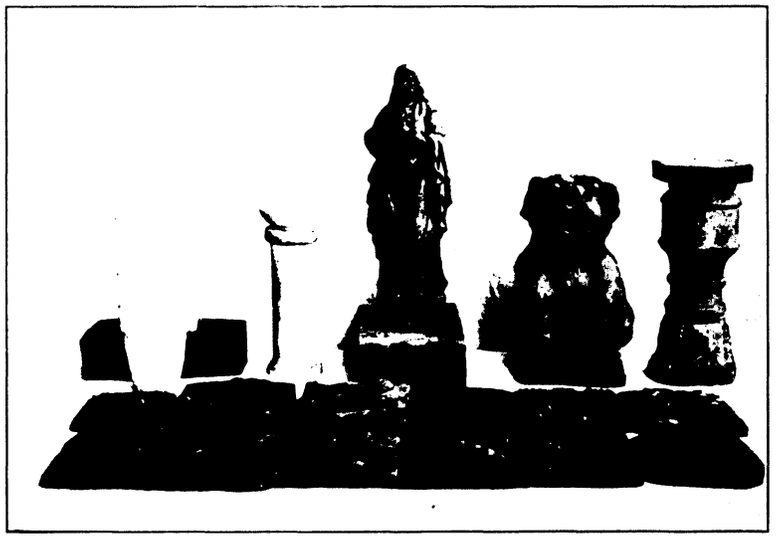
GLAZED WARE (MADE BY FIRST-YEAR STUDENTS).



MODELED TERRA COTTA (MADE BY FIRST-YEAR STUDENTS).

PLATE VII.

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The usual tests made are mechanical, showing shrinkage, color, hardness, warping, cracking, etc. From these tests the usefulness of a clay can be determined and a foundation is laid for further experiments. Below are some results of these tests.

Mechanical tests of clays.

Source.	Shrinkage.		Color.		Cone.	Remarks.
	Air.	Fire.	Air.	Fire.		
	Per cent.	*Per cent.*				
Solsona, Ilocos Norte	11	1	White	White	0.04	With proper handling will make stoneware or porcelain.
Sta. Cruz, Zambales	5	3	do	Clear white	0.04	
Nasugbu, Batangas	3	1	do	Grayish	6	
Los Baños, Laguna	6	8	do	White	6	
Two-thirds Los Baños, Laguna One-third San Pedro Macati, Rizal	10	10	Gray	Dark red	6	Well vitrified. Keep their shape.
Liloan, Cebu	8	3	Brown	do	6	
One-half Los Baños, Laguna One-half Nasugbu, Batangas	4	8	Whitish	Gray	6	Very refractory.
One-half Los Baños, Laguna, white, rock like. One-half Sta. Cruz, Zambales	4	1	do	do	6	

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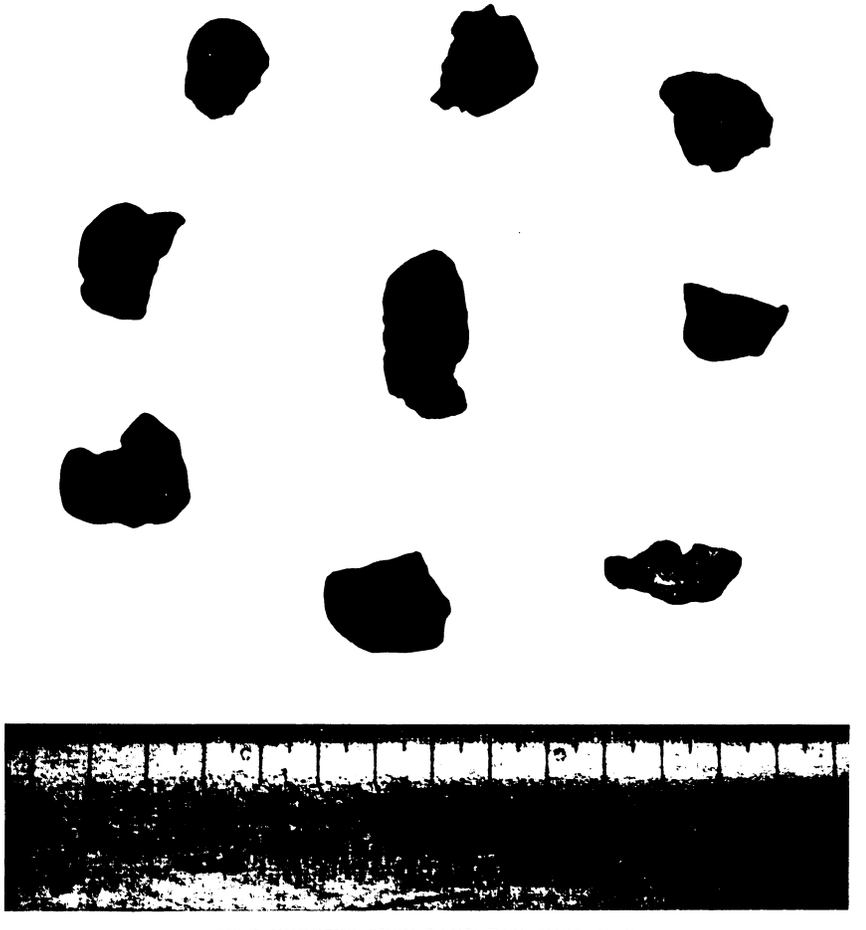

GOLD NUGGETS FROM CANSURAN, MINDANAO.

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GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF THE INTERIOR
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1912

ISSUED BY THE DIVISION OF MINES
BUREAU OF SCIENCE

WARREN D. SMITH
CHIEF OF THE DIVISION

MANILA
BUREAU OF PRINTING
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MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1912

REVIEW OF THE YEAR

By WARREN D. SMITH

The noteworthy features of the mining industry in the Philippines during the past year are the signal success of the Colorado mine in Masbate, a gold-quartz property; the installation and very successful operation of the Gumaus gold dredge on the river of that name in the Paracale district; the erection of a small, but modern, cupola for iron smelting in the Angat iron region; the highly successful utilization of Philippine coal in a gas producer at the Bureau of Science; and the completion of a geologic survey of the lower end of the Bondoc Peninsula, Tayabas Province, a district which is already well-known on account of its seeps of exceptionally high-grade petroleum.

That branch of mining devoted to the winning of gold has been very active, and shows very promising results. Besides the marked success of the Gumaus dredge already mentioned, there are three other dredges operating in the vicinity of the Paracale River, with two more building, and a third is scheduled to begin operations on the lower Umirai River in September of this year. The flotation of the Cansuran Placer Company for hydraulicking the gold-bearing gravels on the river of the same name focuses attention once more on the Surigao Peninsula, long well-known as being fairly rich in gold. The thorough resuscitation of the promosing mineral district of Masbate is indicated by the beginning of the erection of mills for the Eastern and Keystone properties. The Benguet district remains in a badly crippled condition, and, with the exception of the Headwaters mine and the Camote mines which are still (June, 1913) running, operations are practically at a standstill. An increase for the year of nearly a million pesos in gold production in the Archipelago is a remarkable showing in the early stages of the industry. It means much more now than were it simply another million added to a production of several millions already existing. Those who have been the most active, the promoters and operators, have a right to feel proud of their efforts.

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During the past year, the East Batan coal mine, which haa been operating fairly continuously for five years, went into the hands of a receiver and was eventually sold to the Government to satisfy its preferred indebtedness. With the exception of a little grubbing by the natives and some exploratory work in Cebu, there is nothing further to be said about the coal industry. It seems to be peculiarly strange that with so much coal occurring in the Archipelago no successful mine has been started.

In copper there is nothing new to be noted, although there seems to be a renewed interest, judging from the requests for information.

The most important field work carried on by the division of mines of the Bureau of Science during the past year has been the geologic survey of the Bondoc Peninsula, Tayabas. The structure of the region appears to be very favorable for the accumulation of commercial quantities of petroleum, and plans are being projected leading to exploration of the field by drilling.

The discovery of the mineral wolframite has been reported from Antique Province, Panay. A specimen in the provincial exhibit of Antique at the last Philippine Exposition proved to be wolframite, and thus tends to confirm the reports.

A deposit of gilsonite, one of the mineral pitches, in a vein about 6 meters wide, is reported as having been found in Leyte. Samples of this substance, collected by persons of undoubted good faith, have been received at this office.

What may prove to be large deposits of chromic iron and copper have been located in Antique Province, Panay.

The successes and failures of the past year, as well as of preceding years, have clearly demonstrated:

First, that this is not a mining country for a poor man and that any gold rush or any other kind of a mining boom would lead to a great number of bitter disappointments.

Second, the superiority of careful investigation by technically trained men to the guess work and "rule of thumb" methods of many so-called "practical miners."

Third, that there is a legitimate mining industry here which, if properly fostered, will yield in time a large return both to private investors and the Government.

Attention is invited to the figures, on another page of this report, of the mineral production of the Island of Formosa. Formosa is geologically similar to Luzon, is about one-half its size, and the Japanese have been in possession only three years longer than we have been here. This is significant.

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STATISTICS OF PRODUCTION

By F. A. DALBURG

TABLE I.—*Mineral production of the Philippine Islands.*[a]

Product.		1911 Quantity.[b]	1911 Value.	1912 Quantity.[b]	1912 Value.	Increase (+) or decrease (−). Quantity.[b]	Increase (+) or decrease (−). Value.
			Pesos.[d]		*Pesos.*		*Pesos.*
Metallic:[c]							
Iron	metric tons	73	29,159	141	49,272	+ 68	+ 20,113
Silver	fine ounces	3,383	3,606	7,121	8,664	+ 3,738	+ 5,058
Gold	do	9,190	379,906	27,582	1,140,424	+ 18,392	+ 760,518
Copper	kilograms	1,100	600			− 1,100	− 600
Nonmetallic:							
Coal	metric tons	20,000	130,000	2,720	20,200	− 17,280	− 109,800
Clay products			450,000		453,000		+ 3,000
Lime			90,000		92,026		+ 2,026
Sand and gravel			477,344		468,750		− 8,594
Stone			655,795		651,049		− 4,746
Salt	metric tons	18,333	550,000	19,147	574,511	+ 814	+ 24,511
Mineral waters	liters	300,000	60,000	264,871	55,849	− 35,129	− 4,151
Total			2,826,410		3,513,745		+ 687,335

[a] The report covers the calendar year, but where imports are shown the fiscal year, which ends on June 30, is used.

[b] The production given is the quantity sold or shipped, and does not include transportation on sand, gravel, and stone, the values of which are given as at the quarry or point of shipment. Mineral products mined or manufactured, but not sold at the end of the year, are not included. The statistics for iron represent the quantity of iron castings made.

[c] The value of the metallic mineral products is based on the average price of the metals in the New York market. The figures of clay products are only estimates because the large manufacturers alone furnish statistics, while the greatest portion of the products are made by individuals and small producers. The method of collecting statistics is to send a schedule each year to every known operator. Many of the operators neglect to make returns, which decreases the accuracy of the totals for each district.

[d] One peso Philippine currency is equal to 50 cents United States currency.

TABLE II.—*Value of total mineral production of the Philippine Islands, 1907 to 1912.*

By years.		By substances.	
Year.	Value.	Substance.	Value.
	Pesos.		*Pesos.*
1907	234,092	Iron	166,568
1908	1,383,315	Silver	19,936
1909	2,323,367	Gold	2,946,531
1910	2,099,577	Copper	1,116
1911	2,826,410	Manganese	12,500
1912	3,513,745	Coal	627,604
		Clay products	2,177,468
		Lime	341,682
		Sand and gravel	1,770,960
		Stone	2,140,526
		Salt	1,879,879
		Mineral waters	295,737
Total	12,380,506	Total	12,380,507

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TABLE III.—*Mineral products of the Philippine Islands for the calendar years 1907 to 1912.*

Products.	1907		1908		1909		1910		1911		1912	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Metallic:		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*
Iron[a]..... metric tons	132	19,536	96.5	17,500	78.0	31,078	50.0	20,023	37.0	29,159	141	49,272
Silver[b]..... fine ounces	83	110	2,350	2,491	3,000	3,120	1,800	1,944	3,383.	3,606	7,121	8,664
Gold[c]..... do	4,540	187,647	10,510	434,500	11,978	495,194	7,469	308,860	9,190	379,906	27,582	1,140,424
Copper[d]..... kilograms fine			91	52			1,809	464	1,100	600		
Manganese.....						12,500						
Total value of metallic.....		207,293		454,543		541,892		331,291		413,271		1,198,360
Nonmetallic:												
Coal..... metric tons	4,123	26,799	10,035	77,166	30,336	197,184	28,655	176,255	20,000	130,000	2,720	20,200
Clay products.....		(e)		421,628		422,840		430,000		450,000		453,000
Lime.....		(e)		20,000		69,656		70,000		90,000		92,026
Sand and gravel.....		(e)		206,360		325,050		293,456		477,344		468,750
Stone.....		(e)		149,930		311,177		372,575		655,795		651,049
Salt..... metric tons		(e)		(e)		375,368		380,000	18,333	550,000	19,147	574,511
Mineral waters..... liters		(e)	268,440	53,688	401,000	80,200	230,000	46,000	300,000	60,000	264,871	55,849
Total value of nonmetallic.....		26,799		928,772		1,781,475		1,768,286		2,413,139		2,315,385
Grand total.....		234,092		1,383,315		2,323,367		2,099,577		2,826,410		3,514,745

[a] Metallic iron. Value of manufactured product.

[b] Based on average value for the year as follows: 1907, 1.32 pesos; 1908, 1.16 pesos; 1909, 1.04 pesos; 1910, 1.08 pesos; 1911, 1.06 pesos; 1912, 1.22 pesos. Derived from refining of gold bullion; none is mined separately.

[c] Coinage value, 41.34366 pesos.

[d] Smelter output.

[e] Statistics not available.

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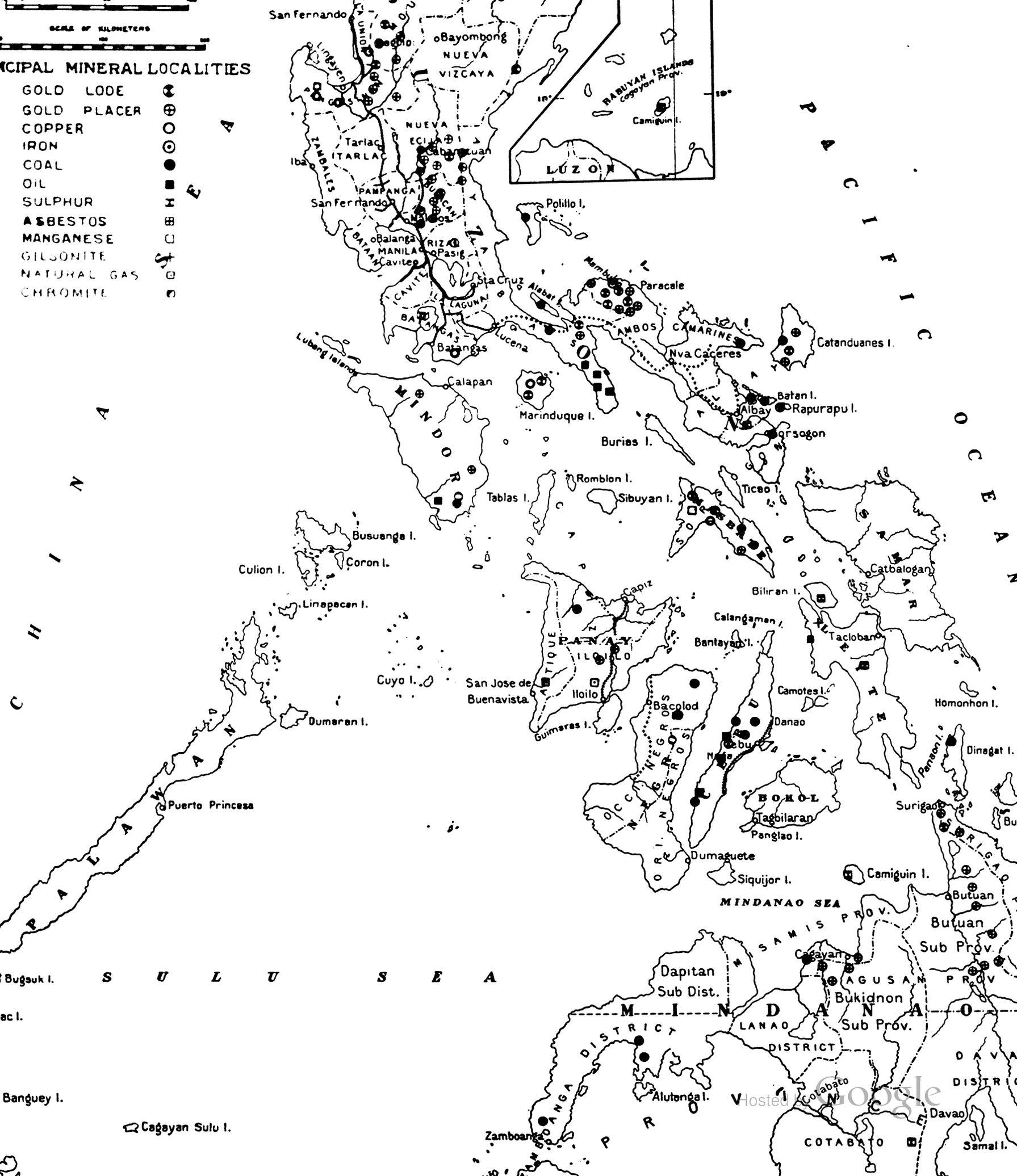
SCALE OF KILOMETERS
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GOLD PLACER
COPPER
IRON
COAL
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SULPHUR
ASBESTOS
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GILSONITE
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Paracale
CAMARINES
Nva Caceres
Catanduanes I.
Batangas
Lucena
Lubang Islands
Calapan
Marinduque I.
Albay
Rapurapu I.
Sorsogon
Burias I.
Romblon I.
Tablas I.
Sibuyan I.
Ticao I.
Busuanga I.
Culion I.
Coron I.
Linapacan I.
Catbalogan
Biliran I.
Capiz
Calangaman I.
Bantayan I.
Tacloban
PANAY
ILOILO
Cuyo I.
San Jose de Buenavista
Iloilo
Bacolod
Camotes I.
Homonhon I.
Guimaras I.
Danao
Cebu
Dinagat I.
Dumaran I.
Puerto Princesa
BOHOL
Tagbilaran
Panglao I.
Surigao
Dumaguete
Siquijor I.
Camiguin I.
MINDANAO SEA
Butuan
Butuan Sub Prov.
Cagayan
Dapitan Sub Dist.
Bukidnon
Sub Prov.
LANAO
DISTRICT
Alutanga I.
Cotabato
Davao
Zamboanga
COTABATO
Samal I.
Bugsuk I.
Banguey I.
Cagayan Sulu I.
CHINA SEA
PALAWAN
SULU SEA
PACIFIC OCEAN
MINDANAO
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TABLE IV.—*Abstract of Formosan mining statistics, 1910.*[a]

Gold	Momme	426,160
	Troy ounces	51,386
Alluvial gold	Momme	15,600
	Troy ounces	1,881
Gold ore	Khan	4,045,102
	Metric tons	15,169
Silver	Momme	493,917
	Troy ounces	59,556
Copper	Kin	1,599,366
	Kilograms	969,313
Coal	Kin	424,868,219
	Metric tons	257,450
Sulphur	Kin	2,981,740
	Kilograms	180,710
Petroleum	Koku	1,442
	Liters	25,143,681

[a] Table IV is taken from an abstract of Formosan statistics published by the Japanese Government, and is given to show a comparison of the relative mineral wealth of this neighboring island and the Philippines.

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STATUS OF MINING CLAIMS

TABLE V.—*Statement of mineral and mining claims filed in the Philippine Islands July 1, 1902, to June 30, 1912.*[a]

Kind of claim.	Province.																														
	Agusan.	Albay.	Ambos Camarines.	Antique.	Bataan.	Batangas.	Benguet.	Bulacan.	Cagayan.	Capiz.	Cebu.	Ilocos Norte.	Ilocos Sur.	Iloilo.	Laguna.	Lepanto-Bontoc.	Leyte.	Mindoro.	Misamis.	Moro.	Occidental Negros.	Oriental Negros.	Nueva Ecija.	Pangasinan.	Rizal.	Sorsogon.	Surigao.	Tarlac.	Tayabas.	La Union.	Zambales.	Total.
Lode:																															
Asbestos					15							16	1																		32
Copper																			43				21	1	139	4		3			211
Copper, rubies, and silver							1																								1
Galena																												4			4
Gold and copper							1									67							47								115
Gold	27		894	3	13	1,284		13								179			8	8		2	3	1	705	43		80		3	3,266
Gold and silver			1																												2
Gold, silver, and copper							1																			12					13
Iron								19																1							20
Iron and copper																								1				1			2
Manganese											28																				28
Silver and lead																												11			11
Sulphur									4																						4
Coal																									4						4
Limestone																									2						2
Not stated		2						1			12		2			44							53	4							118
Total lode claims	27	2	895	3	28	1,287	33	4	12	44	3	290	51	8	2	124	8	850	59	100	3	3,833									

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Placer:																															
Copper																1															1
Gold	74	22	464	2		108	20	1					24	3	57	70	51		357		55	56	141		35	10		1,550
Guano					2		9				1				6			1			15				31			65
Iron							38														4							42
Kaolin					2							20																22
Limestone						2															9				3			14
Manganese										6																		6
Asbestos																											3	3
Marble								1		1					1													2
Ocher																												1
Petroleum									4						8										1,371			1,383
Building stone				1		5			1												25		2					34
Sulphur							4																					6
Lithographic stone							7										2											7
Lime						1																						1
Gravel and building stone																								1				1
Gravel																					1							1
Gravel and stone																					1							1
Rock																					6							6
Gravel and gold																					7							7
Not stated		29					2	1	12	3						8			17	277	5		5		11	5	12	387
Total placer claims	74	51	464	2	1	4	116	76	4	3	17	10	1	20	24	3	73	78	51	2	1	374	277	128	56	146	3	1,451	15	15	3,540
Total lode and placer claims	101	53	1,359	5	1	32	1,403	109	8	3	29	54	3	1	20	314	3	73	129	59	2	1	376	401	136	906	206	3	1,551	15	18	7,373

[a] Under the provisions of the Acts of Congress of July 1, 1902, and February 6, 1905, and Acts 624, 777, 855 of the Philippine Commission. A complete and accurate list of all mining claims as shown by the Spanish records and archives of the former mining bureau has been given by Chas. H. Burritt in *Bull. P. I. Min. Bur.* (1903), No. 2.

In Table V it is impossible to give the surface extent of claims as located, since only approximate distances are generally given in the declaration of location. Also, the great number of claims does not indicate an extensive area because many claims are held from year to year without any development as the holder simply relocates either in his own or another's name whenever it becomes necessary.

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TABLE VI.—*Statement showing status of coal entries filed under Coal Land Law,[a] Philippine Islands, April 28, 1904, to June 30, 1912.*

Province.	Entries filed.		Rejected, canceled, withdrawn.		Action pending.		Survey applied for.	
	Number.	Area.	Number.	Area.	Number.	Area.	Number.	Area.
		Ha. a. c.		*Ha. a. c.*		*Ha. a. c.*		*Ha. a. c.*
Albay	192	10,177 00 00	69	3,760 00 00	120	4,681 00 00		
Bulacan	2	128 00 00			2	128 00 00		
Cebu	256	16,176 00 00	114	7,216 00 00	139	8,824 00 00	1	8 00 00
Mindoro	84	5,343 65 00	31	1,981 03 20	52	3,328 00 00		
Moro	1	64 00 00			1	64 00 00		
Mountain	4	254 00 00			4	254 00 00		
Occidental Negros	2	112 00 00	2	112 00 00				
Sorsogon	66	3,938 00 00	2	120 00 00	60	3,589 80 00	3	192 20 00
Tayabas	78	4,854 00 00	37	2,002 00 00	41	2,752 00 00		
Zambales	1	9 00 00	1	9 00 00				
Total	686	41,055 65 00	256	15,200 03 20	419	23,620 80 00	4	200 20 00

[a] Act of the Philippine Commission 1128, enacted April 28, 1904.

TABLE VII.—*Statement of patents issued for coal, lode, and placer claims in the Philippine Islands, 1902 to 1913.*[a]

Province.	Kind of claim.	Claims.	Mineral.[b]	Area.	Value of patents issued.
				Sq. meters.	*Pesos.*
Benguet	Lode	37	Gold	3,137,388	7,842.97
Lepanto-Bontoc	do	4	do	270,117	675.29
Sorsogon	do	14	do	1,107,001	2,767.50
Total		55		4,514,306	11,285.76
Benguet	Placer	1	Building stone	69,138	172.84
Lepanto-Bontoc	do	1	Copper	55,887	139.72
Nueva Ecija	do	5	Gold	396,340	990.85
Rizal	do	1	Stone	129,880	324.70
Do	do	1	Cement (limestone)	373,276	933.19
Tayabas	do	1	Petroleum	76,620	191.55
Total		10		1,101,141	2,752.85
Albay	Coal	3	Coal	480,000	4,800.00
Cebu	do	2	do	1,280,000	12,800.00
Mindoro	do	1	do	346,180	1,730.90
Sorsogon (Masbate)	do	1	do	320,000	3,200.00
Total		7		2,426,180	22,530.00

[a] All the above data regarding mining claims have been kindly furnished by the Director of the Bureau of Lands.

[b] All mineral lands are sold at 25 pesos per hectare. Coal land is sold at 50 pesos per hectare if more than 25 kilometers from railroad or navigable stream and 100 pesos if within this distance.

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THE PARACALE DISTRICT

By PAUL R. FANNING

The production of the Paracale district for the year 1912 amounted to 399,375 pesos, and showed an increase over the preceding year of 201,375 pesos. The production for the last five years is as follows:

TABLE I.—*Gold production.*

[Values in Philippine currency.]

Year.	Dredgings.	Quartz mining.
	Pesos. [a]	Pesos.
1907	4,000	
1908	152,270	
1909	216,701	
1910	128,505	43,395
1911	198,000	
1912	399,375	
Total	1,056,476	43,395

[a] One peso Philippine currency is equal to 50 cents United States currency.

Out of a total production of 1,099,871 pesos during the past five years, 1,056,476 pesos are due to the work of the dredges. It is safe to believe that the production for some time to come will rest entirely with the dredges and that it will average over a million pesos a year. Indeed, one dredge alone, namely the *Governor Gilbert,* belonging to the Gumaus Placer Company, probably will produce over 500,000 pesos during 1913. The work of this dredge has done much to indicate the importance of the Philippine placers, has resulted in widespread testing of other placer fields, and has encouraged the expenditures of the money in a field of mining which can be made one of the most lucrative and secure forms of investment.

During 1912, the dredge of the Paracale Bucket Dredging Proprietary, Limited, operated practically the whole year as did the dredge on the Malaguit River belonging to the Philippine Dredging Syndicate. The Maximelo dredge on the Maximelo branch of the Paracale River, and the dredge of the Gumaus Placer Company on the Gumaus River operated for about two months.

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The fineness of bullion varies with each dredge as is shown in Table II.

TABLE II.—*Fineness of bullion.*

Company.	River.	Mint returns available.	Gold.			Silver.			Total gold and silver.
			Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	
Gumaus Placer	Gumaus	16	878	863	873	125	112	117	990
Paracale Bucket Dredging Proprietary.	Lower Paracale	8	822	817	820	170	164	116.5	986.5
Maximelo Dredging	Upper Paracale	3	900	799	833	188	091	153	986
Philippine Dredging	Malaguit	6	897	883	889.5	103	092	098	987.5
Average					853.9			133.6	988.5

GUMAUS PLACER COMPANY—PHILIPPINE EXPLORATION COMPANY

The construction of the dredge began early in February of 1912, and the wooden pontoon was launched July 1. The machinery was installed, and digging began on September 25, which meant a total construction period of about eight months. The cost is given at 280,000 pesos. During 1912, the dredge operated on pay gravel for about sixty days, during which time it produced 155,000 pesos' worth of gold. Some anticipated delay was experienced in digging to the pay channel. The ground is especially rich, and large returns are expected.[1]

The soil on this property differs from that on Paracale and Malaguit Rivers, and requires a distinctly different type of dredge and method of operation. No small credit is due Judge Frank B. Ingersoll, general manager of the company, and Mr. William Kane, superintendent, for the careful investigation of conditions before the purchase of a suitable dredge. The alluvium varies in depth and character, containing, at the time of inspection, a sandy clay top almost 3 meters thick, underlain by clay, fine sand, and gravel with a 2.5-meter bottom wash of rather tight coarse sand. The bedrock is a somewhat decomposed granite gneiss.

THE DREDGE

The dredge designed by the New York Engineering Company is of the Empire type, and is radically different from all other dredges in the district. It has a capacity of about 5,000 cubic yards per twenty-four hours, but when operating on pay sands

[1] On July 1, 1913, the Gumaus Company had paid four 10 per cent and two 5 per cent dividends, a total of 50 per cent, in ten months on a capitalization of 500,000 pesos.

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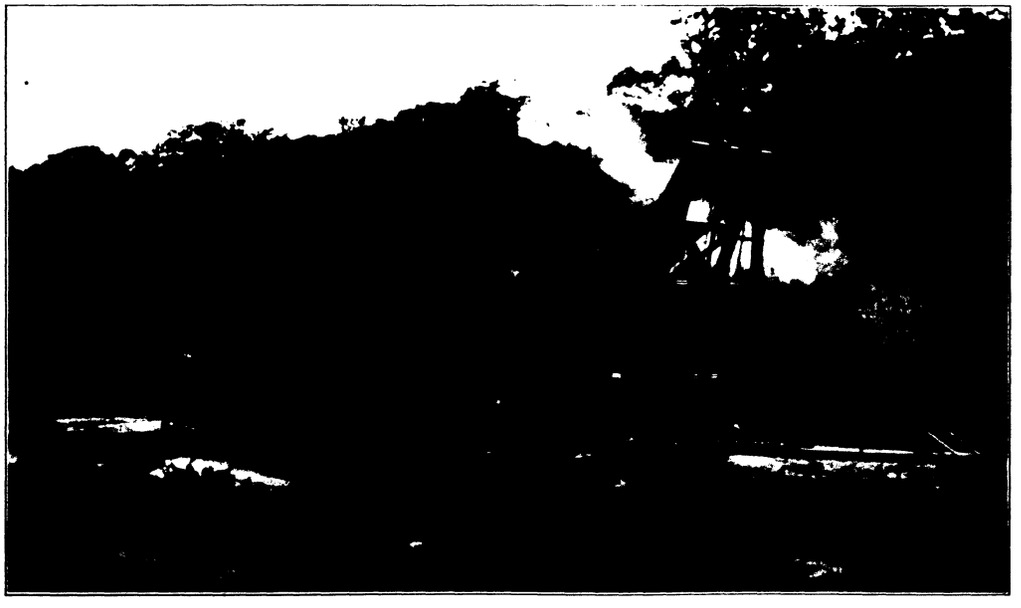

PLATE II. THE GUAMUS DREDGE "GOVERNOR GILBERT."

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about 2,900 yards are handled. The buckets are close connected and have a capacity of 5.5 cubic feet. Mercury is used in the riffles. The tailings are disposed of by means of a stacking belt and sand pump. Rear spuds are used. All operations are controlled by levers from the pilot house. Morris, marine type, engines and the most improved types of machinery are used. As this dredge represents the latest practice, the construction and machinery are given in detail:

The hull is 120 feet long by 46 feet wide, including a 3-foot overhang on each side. Selected Oregon pine is used, and the construction was made especially heavy. The keelsons have a cross section of 12 by 16 inches; the deck, floor beams, and stanchions, 6 by 10 inches; the floor beams are spaced 2.5 feet apart. Two tie beams at the after end of the well are 12 by 10 inches in section, while a third is 14 by 10 inches. The diagonal stays are 4 by 8 inches in section, and the center frames are 6 by 10 inches. The bottom, sides, and deck are made of 4-inch planking, while the well-hole stern and bow use 6-inch board. Tarred felt lies upon the planking, and this is covered outside with a sheathing of 1.5-inch native hard wood. This affords protection from teredos.

The bow gantry, American type, measures 26 feet from deck to top cap. The main and diagonal posts are 12 by 16 inches in section, and the joints are reinforced by 0.25-inch steel plates. The cap, weighing 3.5 tons, is built of structural steel fitted over the gantry frame. The stern gantry measures 60 feet from the deck, and is built of 12 by 12 inch main posts with 8 by 12 inch diagonal stays. Upper truss chords, running between gantrys, are 12 by 16 inches. For even distribution of stress and strain, the center of the dredge is held to the upper truss chord by 2-inch, square, steel rods fitted with turn-buckles.

The digging ladder is built of structural steel, and has a length of 87 feet between centers. Return drip pan is used. The end of the ladder is cast steel. The ladder hanging shaft has a diameter of 12 inches, and rests in a large steel frame containing the driving-gear shafts. This enforces the alignment of the driving mechanism.

The rollers, 16 in number, have a diameter of 16 inches, and weigh 1,500 pounds each. The bearings are grit proof and adjustable. The ladder has a weight of 28 tons exclusive of buckets, rollers, and tumblers.

The lower tumbler which weighs 4 tons has wearing sides lined with manganese steel. A 1.5-inch tie bolt runs through the center of the tumbler shaft in order to prevent the ladder from spreading. The shaft runs in water-tight grease bearings. The upper tumbler which weighs 7 tons has manganese-steel wearing plates; the shafting is 16 inches in diameter, and is driven by double, machine-cut gearings.

The buckets, 84 in number, are close connected, have a capacity of 5.5 cubic feet, and operate at a speed varying up to 22 per minute. The body of the bucket is cast steel; the lip is made of 1.5-inch manganese steel; each bucket weights 1,300 pounds. Manganese-steel wearing plates take up the wear of the tumbles. The link pins are 4.5 inches in diameter, and are American made. The Paracale dredges favor the Hatfield (Sheffield) pins.

The screen is 32 feet long, and has an inside diameter of 5 feet. It is built of 0.5-inch steel perforated plates bolted to the frame, and can easily

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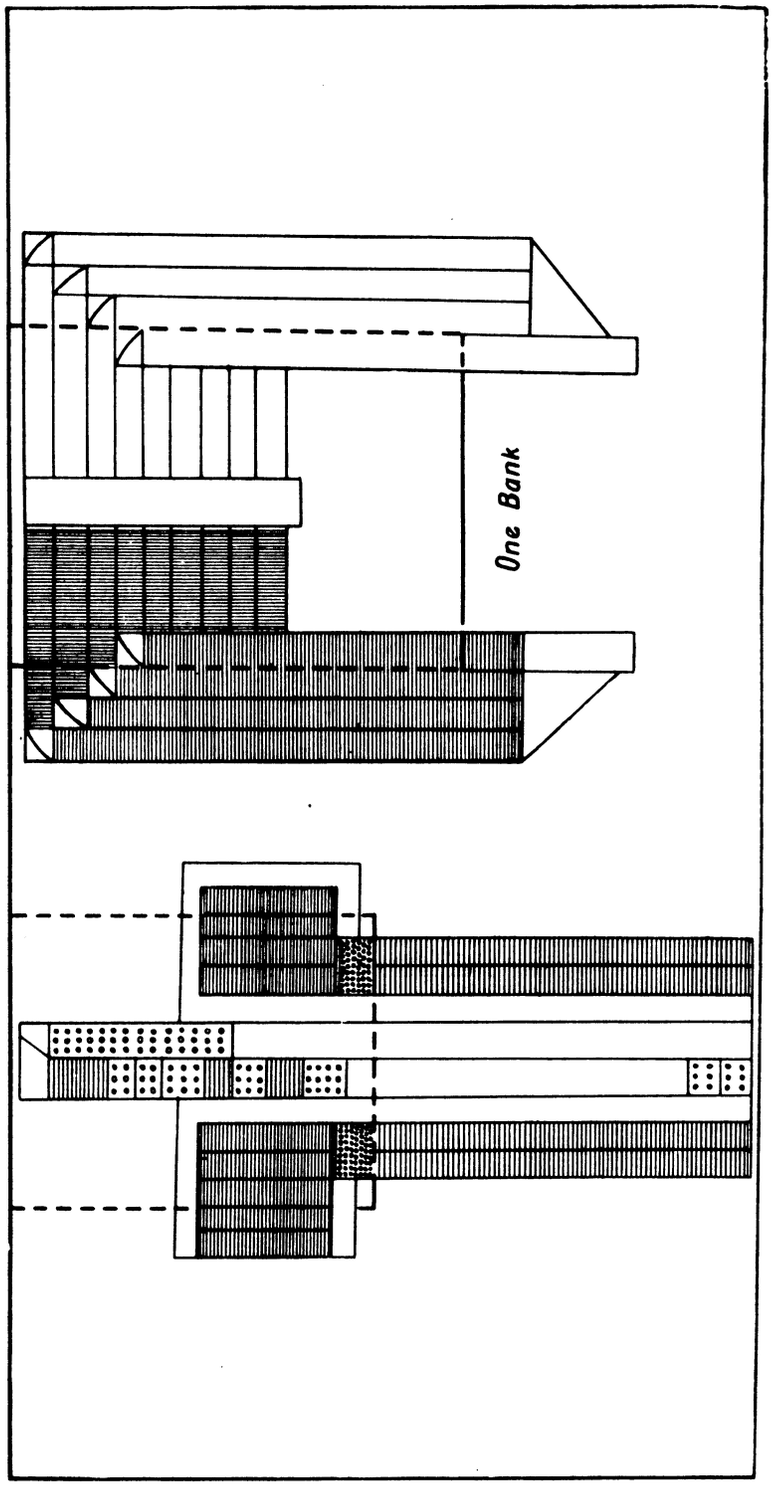

Fig. 1. Showing arrangement of tables on the Parsoale and Gumaus dredges.

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be removed when worn. The perforations grade from 0.25 inch at the upper end to 0.75 inch at the lower end. Flat manganese steel bars are bolted inside to help break up the clay. The screen is driven by friction rollers at each end.

The tables are double-banked; the arrangement of one bank is shown in fig. 1. A total area of about 3,000 square feet is obtained. The tables are of the riffle type, and are set at a slope of 1.5 inches to the foot. The riffles are made of wood covered by 1.25-inch strap iron; the spacing is about 1 inch. The transverse chutes have a width of about 29 inches, while the longitudinal chutes have a width of about 32 inches. In passing from the transverse chutes to the longitudinal chutes, the sand makes a drop of about 6 inches to a 0.25-inch steel plate. Three of the longitudinal chutes, on each side of each bank, are outboard, and lead to a steel stern chute with a 20-foot overhang. Mercury is used in the riffles close to the screen.

The dredge is steam operated from a 300-horsepower Wellington water-tube boiler. Hillside wood is used, thus differing from the other dredges which are favored by the use of mangrove-swamp wood. About 13 cords of wood are used per twenty-four hours.

Fresh water is pumped to the well by means of a 4.5 by 2.75 by 4 inch Worthington duplex pump, and is fed to the boiler by a 4.5 by 2.75 by 4 inch Worthington boiler feed pump which has the advantage of being outside packed.

The main engine is Morris, marine type, 100 horsepower; it runs at a speed of 150 revolutions per minute; is fitted with link-motion reverse gears, and drives the buckets, screen, stacker, and ladder hoist. The ladder hoist, using a seven-eighths lang-lay steel cable, connects by means of a Medard friction clutch, and the barrel is fitted with a compound brake.

The double-speed mine-drum winch is belt driven from a 7 by 7 inch double cylinder, high-pressure Morris engine, running at a speed of 170 revolutions per minute. The drums connect by means of internal expansion friction clutches.

The 12-inch, double-suction, centrifugal pump for the tables runs on outboard bearings, and is direct connected to an 8 by 14 by 10 inch compound Morris engine. Water is delivered through twelve 1.5-inch nozzles, 5 of which are placed at the upper end of the screen and 7 at the lower.

The 8-inch sand pump is made of cast manganese steel, and is belt connected to an 8 by 10 by 14 inch compound Morris engine. The 3 pump engines have the advantage of being identical in size.

All exhaust steam passes to a Baragwanth condensing apparatus through which the water from the high-pressure screen pump passes. The 8 by 10 by 12 inch Knowles wet vacuum pump maintains a 20-inch vacuum.

The conveyor ladder is made of structural steel, latticework type. A 3-foot Jeffrey conveyor belt is used. It is to be noted that the dredges on the Paracale and Malaguit Rivers do not need to use a stacker, owing to the scouring action of the tidal and river currents. Owing to the shortness of life of rubber belting in the tropics, stacker maintenance cost may prove to be high.

The dredge is electrically lighted by means of a 7.5-kilowatt northern direct-current generator, 125 volts, 60 amperes, direct connected to a Kerr turbine running at a speed of 3,600 revolutions per minute.

In operation the dredge is kept to the face by means of a steel girder,

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2 by 3 by 55 foot digging spud weighing 10.5 tons. The wooden, 2 by 3 by 50 foot stepping spud weighs 5 tons. In addition, four 0.75-inch, flexible steel, bow and stern side lines are used.

THE PARACALE BUCKET DREDGING PROPRIETARY, LIMITED

The Paracale Bucket Dredging Proprietary, Limited (Australian capital), which had taken over the property of the Paracale Gold Dredging Company, Limited, continued operation of the dredge throughout the year. An additional wooden hull dredge is being built using close-connected buckets of 7 cubic foot capacity. Screens will not be used. Considerable secrecy surrounds the management of the company, and cost data could not be obtained.

The present dredge is of New Zealand make, using loose-connected buckets having a capacity of 4 cubic feet and running at a speed of 13 per minute. Center and waste chutes are used instead of screens, and, while this method is considered obsolete in certain countries, yet there is much to commend the practice for the peculiar ground being handled. The dredge has a large, single-bank table area, but only half is being used. Hungarian type, removable, wooden riffles are used which lie upon coconut matting and canvas. The arrangement of the tables is shown in fig. 1.

The dredge saves 2 or 3 tons of quartz bowlders per day. These have been accumulating for several years, and are believed to have sufficient value to treat in a small mill erected near the dredge. The mill flow is as follows: Quartz on pile to car; tramming to breaker platform; 16 by 8 inch Blake crusher; belt bucket elevator; grizzly 1-inch openings; 7 by 9 inch Dodge crusher; bucket elevator; 12-ton bin; challenge feeders; one 5-foot Huntington mill crushing through 30-mesh needle-punched screen; 4 by 8 foot amalgamation plate; mercury trap; small 1-foot amalgamation plate; launder with 2 traps; one 18-foot Wilfley table. The concentrates probably will be shipped to a smelter in the United States. The value of the quartz bowlders may prove disappointing, and the mill may not give better than 60 per cent extraction. The ore is adapted to cyanidation, but the quantity saved per day possibly does not warrant the erection of such a plant. The great advantage of the present mill will be in the treatment of the clean-up sands and rich quartz specimens, but a greater return might be obtained by shipping these direct to the smelter and eliminating the mill entirely.

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Until the value of the clean-up sands is exactly known, this point cannot be decided.

The Philippine Dredging Proprietary, Limited, which is controlled by the same individuals as the Paracale Bucket Dredging Proprietary, Limited, has taken over an additional tract of land in the Paracale River Valley, and a dredge of 7 cubic foot bucket capacity is being built. Screens will not be used.

THE PHILIPPINE DREDGING SYNDICATE

The dredge belonging to the Philippine Dredging Syndicate operating on the Malaguit River is Risdon make, old style, with loose-connected buckets which have a capacity of 3.25 cubic feet. About 800 cubic yards are handled per twenty-four hours. The soil passes down a center chute 4 feet wide and 70 feet long, fitted with riffles and punched plate for catching the gold. Mercury is used in the riffles. The alluvium is somewhat sandy, and varies from 10 to 35 feet in depth. The values generally lie in the bottom wash, but in some places gold is found throughout. The bottom wash is quite different from that at Paracale as there is very little quartz and black sand. The values are found along well-defined channels, and careful testing of the ground is required.

MALAGUIT DREDGING COMPANY

The Malaguit Dredging Company has taken over 500 acres of ground on the Malaguit River immediately adjoining the ground worked by the Philippine Dredging Syndicate. A 5.5 cubic foot Bucyrus dredge will be constructed.

THE MAXIMELO DREDGING COMPANY

The Maximelo Dredging Company (formerly known as the Stanley dredge) which is operating on the Maximelo branch of the Paracale River started after a year's idleness. The condition of the machinery caused many shutdowns, and large returns cannot be expected until a modern dredge is installed.

The buckets are loose connected, have a capacity of 5 cubic feet, and handle about 1,000 cubic yards per twenty-four hours. The upper portion of alluvium is stripped for about 10 feet, and passes down a center steel chute, 3 feet wide by 50 feet long. This material is diverted into 2 side chutes fitted with riffles and punched plate for catching the gold. The riffles and plates rest on coconut matting underlain with canvas.

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COMPARISON OF DREDGES

Some essential differences in the dredges are shown in the following table:

TABLE III.—*Dredges in the Paracale district.*

	Philippine Exploration Co.	Paracale Bucket Dredging Proprietary.	Philippine Dredging Syndicate.	Maximelo Dredging Co.	Paracale Bucket Dredging Proprietary (building).
Make	New York Engineering Co.	New Zealand.	Risdon.	New Zealand.	Australian.
Buckets, capacity	5.4	4	3.25	5	7
Bucket speed, number per minute	20	13	12	10	
Operating capacity, cubic yards, 24 hours	2,900	1,200	800	1,000	
Uses screen	X	formerly	formerly		
Uses center chutes		X	X	X	X
Stacking ladder	X				
Tables and chutes:					
Approximate length in feet	1,300	632	70	153	
Approximate area in square feet	3,000	[a] 2,200	245	459	
Mercury used	X		X		
Spuds used	X				

[a] 1,200 square feet used.

The older types of dredges were loose connected, but the Gumaus is close connected, and the new dredges now being constructed likewise will be close connected. The Paracale and Malaguit dredges formerly used screens, but these were discarded and a lower working cost resulted. It is believed that for the Paracale dredge an equal saving of the gold is made. The fact that the new Paracale dredges will use chutes instead of screens indicates the success of this method for their ground.

All the dredges use bow and side lines except the Gumaus which uses rear spuds. Operation on spuds is believed to give a greater yardage, permits a better cleaning of the bedrock, and saves wear and tear on the boat.

All are equipped with save-alls, and the Gumaus has, in addition to this, a return drip pan which minimizes the escape of dirt. The Gumaus has about double the capacity of all other dredges, and uses over double the table area. The extraction should be high, especially in view of the use of mercury which saves much fine gold.

The use of screen and stacker, as well as the necessity of treating all the material on the tables, adds to the working costs on the Gumaus, but the superior machinery and larger capacity ought to

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give the lowest cost in the district. Direct comparison of Australian and American practice cannot be made, owing to the great differences in the soil worked on the three rivers.

The Paracale soil toward the mouth of the river has the values concentrated in a few feet of pay gravel at the bottom, varying in depth from 9 to 18 meters. On top of this gravel there lie from 7.5 to 15 meters of stiff clay and coral containing practically no gold. In operation, this worthless material is stripped and is allowed to run to waste down a waste chute. When pay gravel is reached, it is sent down the center chute, and the sand passes through undercurrents to the riffle tables. These are in use for about eight hours out of the twenty-four.

The soil on the Gumaus is somewhat shallower, more sandy, and, while the values are mainly in the bottom wash, some values are found in the upper sands. For this reason all of the sand is run over the tables.

THE PARACALE VENTURE CORPORATION

The Paracale Venture Corporation attempt to work their holdings by means of drift mining. A shaft was sunk to the bottom wash which was said to run about 80 pesos to the cubic meter in free gold alone. Much of the pay gravel was cemented and required disintegration for complete saving of the free gold. No actual drifting was done, and, while difficulties forced an early shutdown, it is the intention to continue the work.

BLACK SANDS

The first ground worked by the Paracale dredge contained rich black sands which to a certain extent have concentrated near the mouth of the river. In October of 1912, a working test was made on the dredge (then some distance up the river) with the aim of saving a larger percentage of the black sands running to waste. While working on the bottom wash, the riffles were cleaned hourly. The gold was then cleaned from the black sands by the usual amalgamation, and the sands were assayed and showed a value of about 6 pesos per ton and a tonnage for the dredge of about 1.5 tons per eight hours. The dredge "strips" for sixteen hours, during which time the gravel and sand pass directly to waste. It is evident then that a much larger tonnage of black sands could be obtained, provided all of the fine gravel is diverted to suitable tables. The test fully demonstrated that in order to save black sands sizing is necessary, as otherwise the fine black sands and gold have no chance to settle in the riffles against the force of far larger grains of quartz.

The black sands along the bench were tested by concentration

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in pans, but the concentrates were far too low in value to pay for the cost of treatment.

The question of treatment of black-sand concentrates after being saved on the dredge has been fully described,[2] and subsequent tests have confirmed these results. However, the advantage of saving more of the black sands does not seem as encouraging as before.

QUARTZ MINING

Notwithstanding the fact that practically no work was performed in quartz mining during 1912, it has not yet been proved that the mines are valueless. It is the intention of the Philippine Exploration Company to reopen the San Mauricio mine at Mambulao, and while it is known that the present 20-stamp amalgamation and concentration mill is not adapted for making an economical saving of values the owners hope that by driving a sea-level tunnel to the vein, sufficient ore can be opened up to warrant the installation of a cyanide plant for the profitable treatment of the ore.

The Tumbaga mine probably will be reopened as exceedingly rich ore has been taken out in the past, and the possibility still remains for the uncovering of additional ore bodies.

The district as a whole has disadvantages which can only be compensated for by ore of superior value. Shaft work and pumping generally are required as tunnels produce little "backs" in comparison with their length. The ore shoots in the veins are very irregular, and it is impossible to tell the good ore from the bad. The ore is very hard, and in many cases the walls require considerable timbering.

[2] Fanning and Eddingfield, *Phil. Journ. Sci., Sec. A* (1912), 7, 213–253.

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THE ARAROY DISTRICT

By PERCY D. KINCAID

Since this district has been covered in previous reports by both Eddingfield [1] and Fanning,[2] I shall limit this article to the recent changes which have taken place.

The Araroy mining district is the leading quartz-gold mining district in the Philippines, and promises to increase its lead by the erection of two new mills on the Keystone and Syndicate properties. At present the Colorado is the only producing mine in the district with an average of 57,000 pesos per month. Its total production for the year 1912 was 681,000 pesos or 16,329 fine ounces of gold and 4,248 fine ounces of silver. The year 1913 should show a large increase over this amount as a result of various improvements which are to be made in the mill.

THE COLORADO MINE

On this property there have been only minor changes during the past year, and both the mill and mine are continuing the consistent progress which they have maintained for months.

The second level is opened for a length of 700 feet (213 meters), showing a well-defined vein of from 8 to 15 feet (2.5 to 5 meters) in width. On this level there is a crosscut of 70 feet (21 meters) to the east which cuts a vein 4.5 feet (1.3 meters) wide of 18-peso ore. A third level 100 feet (30 meters) below the second and a sixth level, 400 feet (120 meters) below the second or about 1,000 feet (305 meters) below the highest point on the outcrop, have already been started. A crosscut from the level of the mill head is being run through the property; it is now 150 feet (45 meters) long, and it is estimated that it will cut the big vein at 1,300 feet (about 400 meters) from the entry.

The Colorado has taken over the claims lying between it and the Keystone property, and, therefore, it should be possible to open up the levels for a still greater length.

The square-set system is used in the stopes. The filling is drawn from the stopes above to the stopes below. Oregon pine treated with carbolineum paint is being substituted for native timber. It has been found that it lasts longer, is easier to handle, and costs less, the cost being 1.10 pesos per ton of ore mined.

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[1] *Min. Resources P. I. for 1910, Bur. Sci., Div. Min.* (1911), 10.

[2] *Min. Resources P. I. for 1911, Bur. Sci., Div. Min.* (1912), 4.

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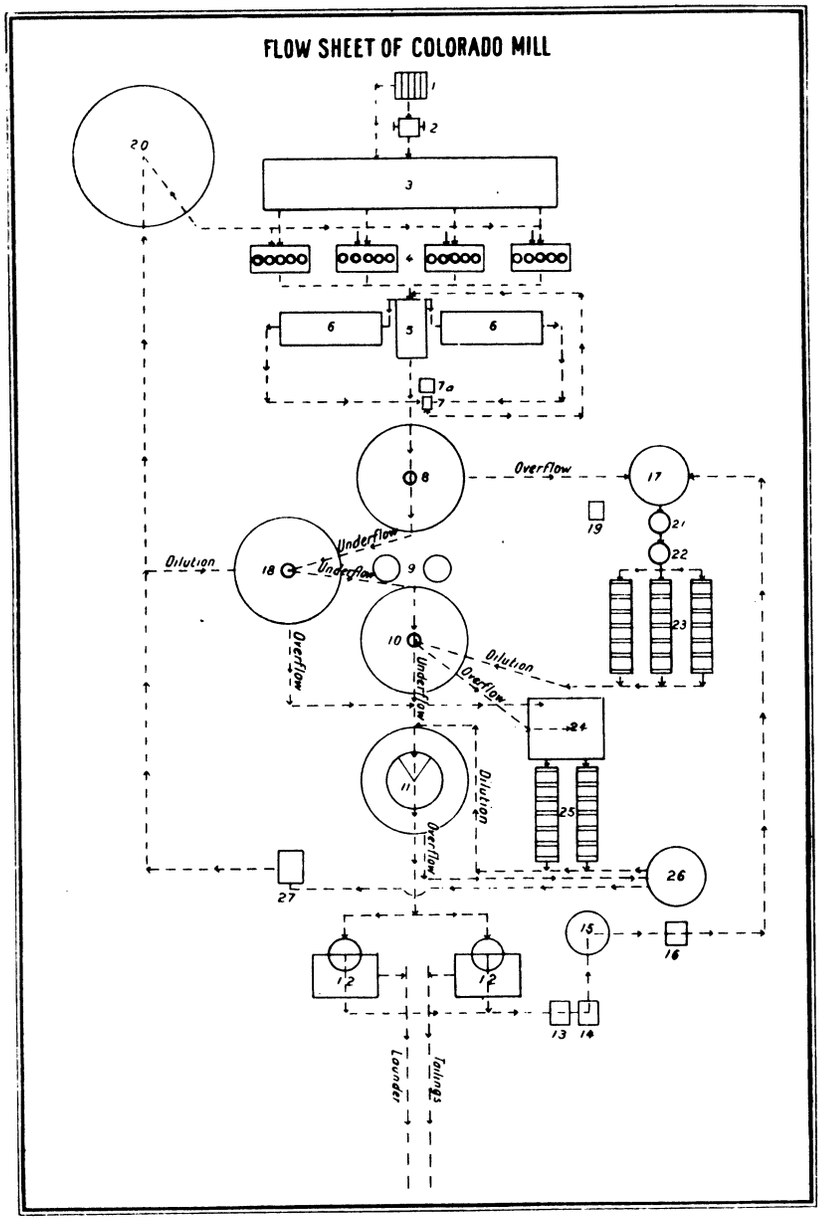

1 8 by 8 foot grizzly.
2 10 by 20 inch Blacke crusher.
3 ore bin.
4 20 stamps; Challenge feeders.
5 Dorr classifier.
6 two 5 by 18 foot tube mills.
7 air lift.
7a bucket elevator.
8 28 by 14 foot Dorr thickener.
9 two pachuca tanks (not in use).
10 28 by 14 foot Dorr thickener.
11 20 by 8 foot Traylor agitator.
12 two 11 by 6 by 8 foot Oliver filters.
13 wet vacuum pump.
14 dry vacuum pump.
15 12 by 10 foot solution tank.
16 5 by 8 inch Triplex pump.
17 10 by 12 foot gold solution tank.
18 28 by 14 foot Dorr thickener.
19 Triplex pump (not in use).
20 28 by 14 foot storage tank.
21 6 by 6 foot overflow tank.
22 gold solution tank.
23 three sets 7-compartment zinc-boxes.
24 clarifying box.
25 two sets zinc-boxes.
26 20 by 8 foot barren solution tank.
27 solution pump.

Fig. 2. Flow sheet of Colorado mill.

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The capacity of the mill[3] varies, but approximates 100 tons a day. It will no doubt increase as improvements are made. One of the most important alterations is the introduction of a filter of another type to replace the Oliver. With this the superintendent, Mr. Filteau, expects an increase in the amount of ore treated, the percentage extraction, and a longer and more complete wash.[4]

The screens in the batteries have been changed from 6-mesh to 4, giving the stamps a larger capacity.

The Dorr thickeners, arranged in series, have been increased to 3. Formerly the underflow from the first thickener entered 2 Pachuca tanks where it received air agitation. Since about 90 per cent of the gold goes into solution before it reaches these tanks, it was thought advisable to run without them. Now that they have been cut out, it does not seem that the extraction is decreased appreciably. The pulp instead of entering the Pachucas meets the barren solution from the upper zinc-boxes and is conveyed by a launder to the second thickener. The dilution of the pulp is not as great as formerly, the reason given is that the slimes are slow in settling in the thickeners. The cost of cyanide and lime is about 0.75 peso per ton of ore treated.

In the near future one can expect other changes in the Colorado mine which will tend toward larger capacity and reduction in expenses.

The following figures were taken from the annual report of the Colorado Mining Company for the year ending December 31, 1912:

	Tons.
Ore mined	31,417
Ore from dump	1,752
Ore milled	33,169
Ore averages pesos per ton	23.06
Cost per ton.	Pesos.
Development	0.602
Stoping	4.295
Milling	5.577
General and marketing	0.532
Total operating expenses	11.006

[3] The screen test of the classifier sands [*Min. Resources P. I. for 1911, Bur. Sci., Div. Min.* (1912), 11] as submitted to us for publication was in error and the conclusion drawn therefrom that the Dorr classifier was not classifying properly must be modified. In addition, it should be understood that the cost of the mill, stated on page 14 to be excessive, was due to local conditions and does not reflect upon the management.—P. R. PANNING.

[4] This should not be taken as a reflection on the Oliver; it only means that it is not altogether suitable to the conditions found here.

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Development work.

	Feet.
Winzes	96
Raises	616
Drifts	1,312
Crosscuts	158
Total	2,182

	Tons.	Value per ton.
		Pesos.
Ore reserves	217,215	21.54

At the rate of 36,000 tons mined a year, there is an ore reserve for six years.

SYNDICATE MINE

A cyanide mill is being erected on the Syndicate property. When completed it will have a capacity of 100 tons. The process of extracting the gold is the all-sliming continuous decantation method. The crushing and grinding of the ore is accomplished in four stages.

The ore is to be conveyed from the mine by skips on a surface-gravity three-rail tram which is operated in balance. On its arrival at the mill it is dumped on a 3-inch grizzly which feeds the oversize to a Sturtevant roller jaw crusher, while the undersize with the product of the crusher falls on a belt conveyor and is carried to the ore bin. From the ore bin the ore goes to a Hardinge ball mill, the product of which is carried by a launder and air lift to the classifier. The slimes from the classifier go to the first thickener, while the oversize is fed to 2 Hardinge pebble mills. The product of these mills is carried back by launders to the same air lift which raises it again to the classifier to be reclassified.

Since the flow sheet (fig. 3) shows clearly the stages of the process, very little explanation will be necessary. The overflow from thickeners 1 and 2, being the rich solution after clarification, goes to the zinc-boxes. The barren solution from the boxes is pumped to the storage tank 35 feet above the tube mill floor, and is used to dilute thickeners 3 and 4 and, if necessary, a portion of 5. The overflow decanted from thickeners 3, 4, and 5, being low grade, does not pass through the zinc-boxes. It is pumped like the barren solution to the low-grade storage tank, and is used in the ball and pebble mills. It is used for dilution in the launders (5:1), the dilute pulp going to the classifier and then to thickener 1, and it also dilutes thickener 2 (about 4:1). The

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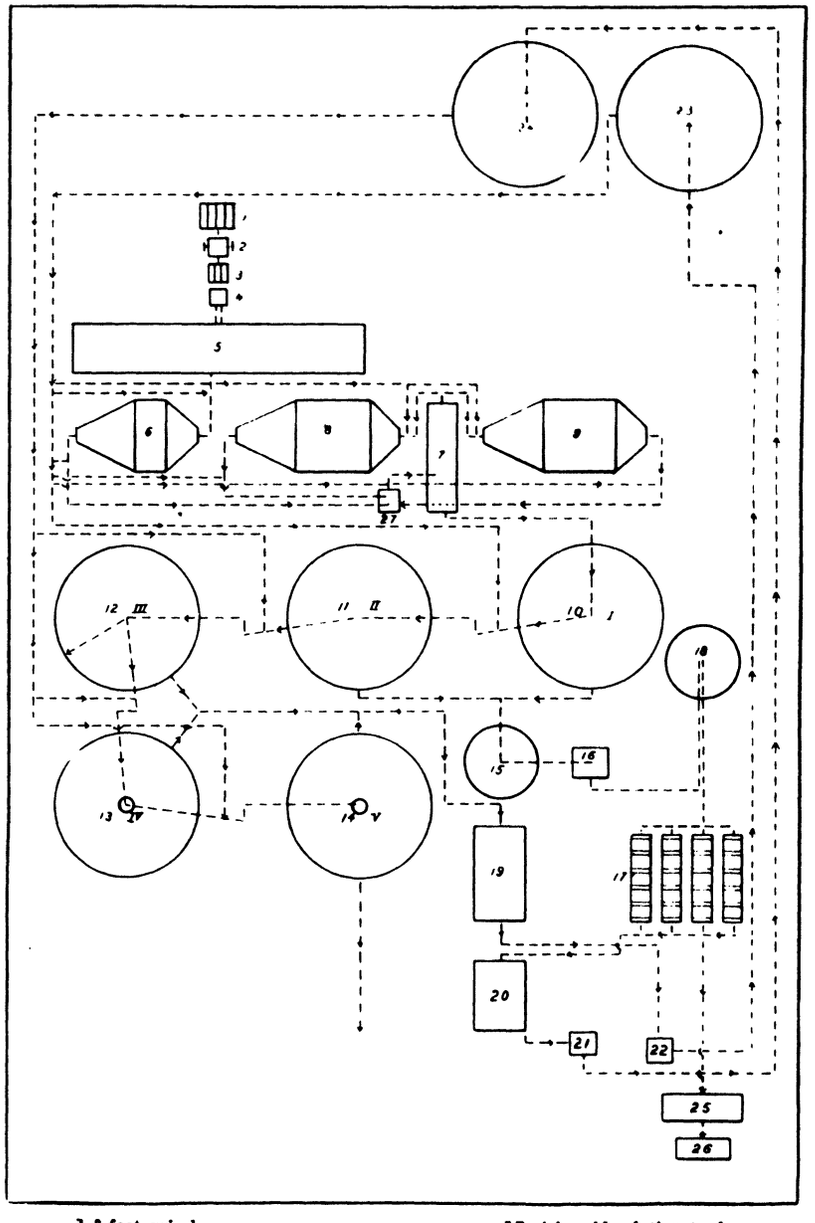

1 8-foot grizzly.
2 Blake rock crusher to 4 inches.
3 ½-inch grizzly.
4 Sturtevant roller jaw crusher to 1 inch.
5 ore bin.
6 Hardinge ball mill 6 feet by 16 inches.
7 Dorr classifier.
8 Hardinge pebble mill 6 by 6 feet.
9 Hardinge pebble mill 6 by 6 feet.
10 Dorr thickener 12 by 30 feet.
11 Dorr thickener 12 by 30 feet.
12 Dorr thickener 12 by 30 feet.
13 Dorr thickener 9 by 30 feet.
14 Dorr thickener 9 by 30 feet.
15 rich gold solution tank.
16 clarifying filter press.
17 zinc-boxes.
18 rich gold sump tank.
19 low grade solution sump.
20 barren solution sump.
21 pump.
22 pump.
23 low grade solution tank.
24 barren solution tank.
25 roasting furnace.
26 melting furnace.
27 air lift.

Fig. 3. Flow sheet of Syndicate mill.

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discharged thickened pulp from No. 1 is diluted and raised over to No. 2 in one operation by an adapted hydraulic elevator, using the low-grade solution from the storage tank, which gives a 35-foot head. Thickeners 3 and 4 are diluted in the same way, except instead of the low-grade solution the barren solution is used as stated above. Air lifts to be used if necessary will probably be placed between all thickeners. No. 5 is diluted by using as much water as possible, this being governed by the amount necessary to replace the discharged solution, while the balance is made up by a weak cyanide solution. It should be observed that each thickener is diluted separately from the storage tanks and that the solution flow is not against the pulp flow. The first three thickeners are deeper than Nos. 4 and 5, to permit the use of more wash solution.

The power plant will consist of a Benz Diesel engine, using crude oil.

KEYSTONE MINE

A mill is being constructed upon this property under the superintendence of Mr. A. C. Cavender. The plant consists of crusher, two 10-foot Lane slow-speed mills, 4 Dorr thickeners, and necessary stock solution and supply tanks, all driven by a 60-horsepower Bolinder internal combustion (crude oil) engine, with a 15-horsepower Remington as auxiliary for stirring machinery, electric light, etc.

This plant is expected to grind from 60 to 80 tons per day to 100-mesh, tests of the ore by Von Schulz and Low, of Denver, having determined an extraction of 93.4 per cent of values at that degree of fineness. The flow sheet shows continuous decantation to be the process, the thickened slimes from one thickener being diluted in the next thickener by the clear solution from the thickener next below, thus the pulp running in one direction and decreasing in values meets the solution going in the opposite direction and increasing in values.

It is to be noted that work upon the construction of this plant was commenced March 1 of this year, and at time of writing (August 21) the mill is expected to be in operation on or before September 1, or six months from date of commencement of construction.

When the Syndicate and the Keystone mills are completed there will be three mills in operation in one locality all using the all-sliming cynide process with different machinery. It will be not only interesting to note the results, but also of great importance to the erection of future mills in the Islands.

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BAGUIO DISTRICT [1]

By WARREN D. SMITH

The Baguio district has not yet (June, 1913) recovered from the disastrous typhoon of October, 1909, which could not be anticipated, and from ill-advised expenditures on two or three unproved properties. However, the lessons taught by this disaster and these mistakes will be of great value to future operators.

During the year development work has proceeded slowly on the Kelly group of claims on Gold Creek, but practically all other work along this stream has been suspended. Previous to this year, Mr. Colgan, a pioneer prospector of the country, was doing prospecting on a group of claims known as the Madison and Antamok Valley, farther down this stream, but his death has stopped this work for a time.

The Major mine, situated on Major Creek, has been closed down for some time, and but little more than assessment work has been done on that group of claims.

Mr. Calvin Horr continues his development work on the Ascension group of claims on Kias Ridge.

All work has been abandoned on the Bua property on the Antamok River, but across the stream the 3-stamp mill on the Camote property is still being operated by Mr. John F. Reavis. Mr. Reavis installed a small cyanide plant which he operated for a time, but he has since abandoned it.

Farther up the Antamok River there are 2 stamp mills, the first one is the 3-stamp mill, made by the local firm of Taylor & Co., which is being operated by Messrs. Ebert and Proback. They brought down their first bar of bullion in the early part of December. As they are only using amalgamation, the recovery is not high. The energy and persistence which has characterized the work of these men, operating under considerable difficulties, is greatly to be commended.

Above this mill is located the well-known Headwaters property which has had a checkered career, passing from one management to another in rapid succession. The present management, Messrs. Smith, Bell & Co., Manila, is making every effort to

[1] Full descriptions of this district have appeared in previous issues of The Mineral Resources and in The Philippine Journal of Science.

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place this company on a sound financial basis, but it must be said in justice to them that they are working under considerable difficulty and that the elaborate equipment of the mill is about a year ahead of that warranted by the state of the mine. They have difficulty in keeping the mill supplied with ore. The latter has been overhauled, and it seems to be doing well under the supervision of Mr. Aitken in spite of having to operate without the filter. The mechanism of the filter was too complicated to use here. It has been abandoned, and the company will probably install one of a different type. This company is now working in a tunnel known as B No. 2. The behavior of the vein in this tunnel is not very encouraging as it pinches down to only a few inches in places and then widens perhaps to several feet. The gangue is quartz and calcite with more or less manganese. The strike is north 65° east with dip to the north.

The most serious and immediate difficulty at the mine is a shortage of timber. The original locators of this property were singularly negligent in not acquiring sufficient timber ground adjacent to their claims, and practically all the timber on their claims has been cut off. The claims on which timber is situated are in the possession of others, and up to this time no acceptable terms have been arranged. If some arrangement can be made, the work of the mine will not be interfered with.

At the close of each rainy season, the Headwaters Company has to resort to gasoline as a source of power. The cost of gasoline in this district is too great to justify its permanent utilization as fuel for any but very rich ore.

A recent visit to this district has shown that there is imperative need for a mine warden in the district to supervise the locating and recording of mining claims.

This district will recover in time, but before then several things are necessary: (1) More bona fide mining men and fewer speculators in the district, (2) capital, (3) consolidation, and (4) a hydroelectric power plant on either the Agno or the Antamok River.

The practice of indiscriminate staking of claims all over the hillside, where there is very little prospect of finding valuable lodes, is undesirable, and it is hoped that the Government will take measures to prevent the staking of claims purely for timber rights. A stringent tax on locations ought to prevent future cases of this nature.

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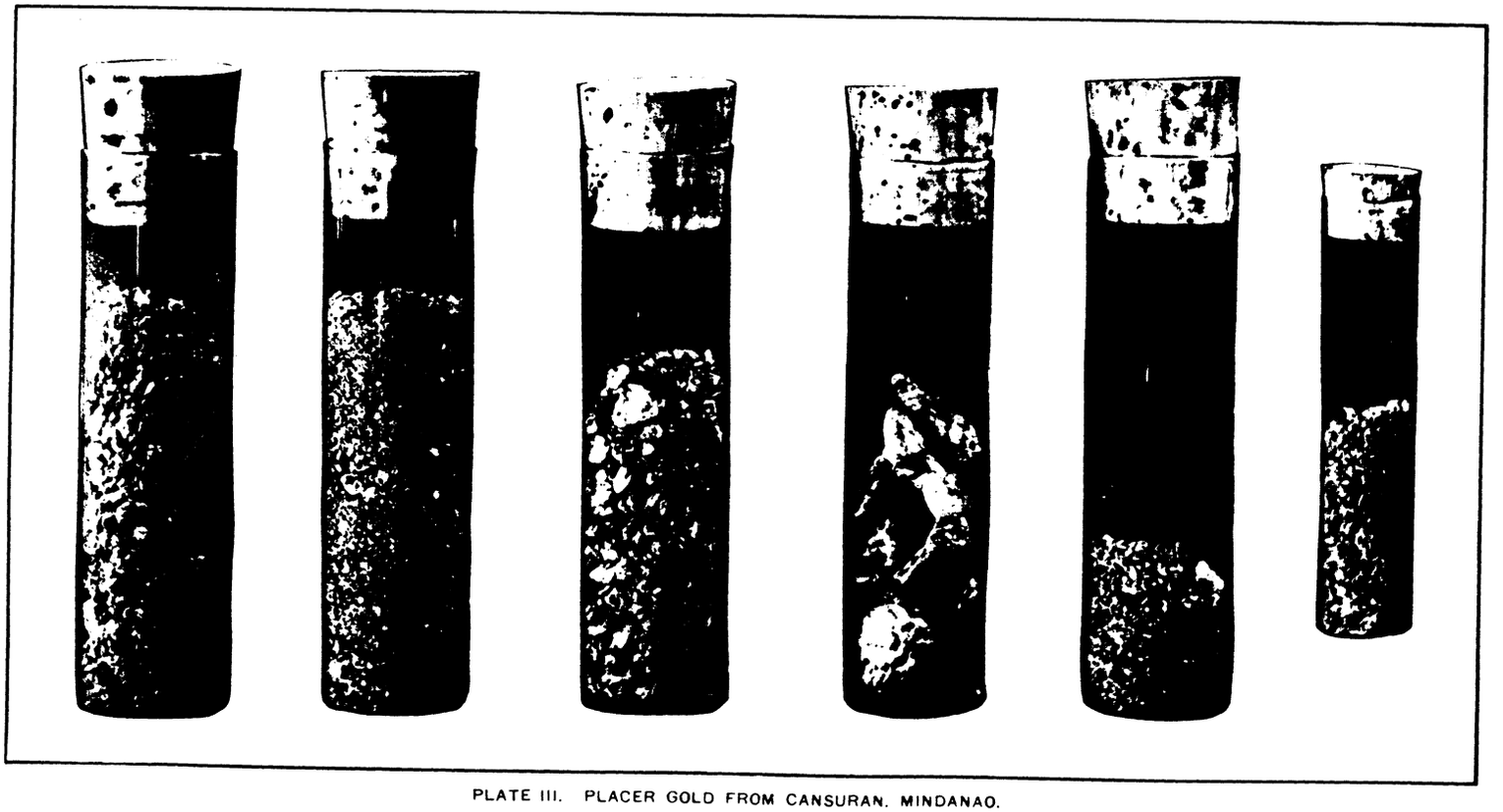

PLATE III. PLACER GOLD FROM CANSURAN, MINDANAO.

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OTHER DISTRICTS

By F. T. EDDINGFIELD

Umerai district.—This district is located in the northern part of Tayabas Province along the Umerai River and its tributaries, especially along the Angelo branch. The Umerai River, which rises about 70 kilometers northeast from Manila near the boundary line between Bulacan and Tayabas, flows west of north and empties into the southern part of Dingalan Bay. It is called Rio Umerai o Umierey on d'Almonte's map. Apparently gold had not been found at that time. This, I believe, is the only important district that had not been previously discovered by the Spaniards and marked upon this map.

Gold was first reported from here by a party sent out by Messrs. Squires, of Squires and Bingham, Manila, who now hold 19 claims near the mouth of the river. Soon afterward Mr. A. Heise located a large number of claims, part on the flat above the Squires' holdings, but the majority along the Angelo branch of the Umerai. These claims are held by the Luzon Gold Company. A large portion of this ground is suitable for hydraulic working of the placers; in fact, sufficient experimental work has been done with a small hydraulic plant to prove its economy. One of the largest nuggets discovered since American occupation was found on this ground; its weight was about 30 grams. This company claims to have 2,000 acres of dredging ground.

A portion of the Squires' property was thoroughly tested by an Australian company, and, while no definite figures have been given out, it has been reported to run better than a "shilling a cubic yard." This company is said to have contracted to place a dredge on the property by September 1, 1913.

Mountain Province.—Some renewed interest of late has been taken in the Mancayan copper deposit. It appears to be valuable enough for economical mining, and is only handicapped by the difficulties of transportation and fuel.

Nueva Ecija.—Prospecting is still being carried on in placer ground and in quartz veins. Two large veins are reported near the head of the Chico River.

Zambales.—A few prospects have been found carrying gold

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and copper. Very little prospecting has been done in the mountains of this province, but they appear favorable for ore deposits.

Mindanao.—The Cansuran placer deposit has been tested in part by Mr. H. Y. Hanlon who reported that 325 acres of tested ground ran 44 centavos per cubic yard. He reports 2,627 acres of possible workable ground out of which he examined 1,920 acres. These figures check very closely with the estimate made by the Bureau of Science in 1912 and published in The Mineral Resources. This property has been taken over by a local company called the Cansuran Placer Company, with a capital stock of 1,000,000 pesos.

The placers along various branches of the Agusan River are also receiving some attention. Mr. A. Heise has recently gone to test property located by Captain Wilson.

Very little has been heard from Misamis, but several rumors are afloat concerning good findings in the Pigtao district.

Marinduque.—Very little work has been done on this island. However, several lead-silver deposits have been discovered which may prove to be valuable.

The finding of valuable placer deposits at Cansuran and Umerai and the formation of large companies in Paracale have stimulated placer prospecting. Several prospectors are working along the east coast of Luzon which appears to be favorable for placer deposits. Very little prospecting has been carried on north of Dingalan Bay on account of the inaccessibility of the country. This part of the country presents a very good field for investigation.

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THE IRON INDUSTRY IN 1912

By F. A. DALBURG

The iron industry in the Philippine Islands during 1912 shows a great increase over all previous years. The total value of iron produced in 1912 was 49,272 pesos. This figure represents an increase of 20,113 pesos over 1911, and exceeds the production of the previous best year, 1909, by 18,194 pesos. These figures represent the value of plowshares and points cast directly from the furnace.

In Table I are given the metric tons of iron ore mined and metallic iron produced from 1907 to 1912, inclusive:

TABLE I.—*Production of iron ore and iron castings, 1907 to 1912, in metric tons.*

Years.	Iron ore mined.	Iron castings produced.
1907	380.0	132.0
1908	289.5	96.5
1909	234.0	78.0
1910	150.0	50.0
1911	219.0	73.0
1912	352.5	141.0

During the year several furnaces have been abandoned, but a corresponding number of new furnaces nearer the charcoal supply have been built. Several new operators are constructing furnaces which will probably be in operation during 1913.

A general résumé of the iron industry as obtained from the mine reports is given in Table II.

TABLE II.—*Mines report of iron production for 1912.*

Plowshares:		
First size	pairs	7,407½
Second size	do	5,032½
Third size	do	8,649
Plow points	do	18,171½
Ore used	metric tons	352.5
Charcoal:		
Kilns fired		47
Metric tons used		684.6
Furnaces in operation		13
Times in blast (all furnaces)		53
Days in blast (all furnaces)		558
Iron produced	metric tons	141
Market value of product	pesos	49,272

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The iron produced in the Philippines is used solely for the manufacture of plow castings. No other implements and no pig iron are produced. Locally, the small Chinese foundries also produce plow castings, pans (*cauas*) for boiling sugar, and frying pans from old iron scrap and imported pig iron. The larger foundries all use pig iron and scrap iron with some ferromanganese, and make castings of all kinds.

The Insular Collector of Customs has furnished the following quantity and value of pig iron imported through the various entry ports of the Philippine Islands during the fiscal year ended June 30, 1912:

Port.	Quantity.	Value.
	M. tons.	*Pesos.*
Manila	1,528	48,552
Cebu	5	190
Iloilo	182	8,278
Total	1,715	57,020

Of the total quantity, 1,682 metric tons, valued at 55,980 pesos, were imported from the United Kingdom, while the balance of 33 metric tons, valued at 1,040 pesos, came from the United States.

The principal grades of pig iron imported at the port of Manila are "Gavan" Nos. 1 and 3; "Redjar;" "Cambroc" No. 8; "Gartsherie" Nos. 1 and 3; and "Cleveland."

It is impossible to show the value and quantity of products obtained from the second fusion in the foundries as a considerable number of castings are of special design and no statistics are available from the manufacturers.

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In Table III are given the total imports of iron and steel goods for the years 1909 to 1912 inclusive, as compiled from the annual reports of the Insular Collector of Customs.

TABLE III.—*Imports of iron and steel goods.*

Article.	Twelve months, ending June 30.							
	1909		1910		1911		1912	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*
Pig iron	222	21,762	1,234	39,876	1,326	53,076	1,715	57,020
Bar iron	2,148	152,892	2,249	126,570	2,992	185,146	2,568	138,940
Bars and rods of steel	1,990	153,684	4,208	319,694	7,562	558,532	14,090	880,896
Rails:								
Iron	431	44,508	438	31,566				
Steel	404	25,250	11,783	687,706	5,093	363,812	11,564	698,446
Sheets and plates:								
Iron	5,541	711,724	8,348	1,069,318	11,183	1,560,752	12,797	1,686,710
Steel	1,125	98,078	1,221	109,740	1,483	108,504	1,399	108,926
Structural iron and steel	1,154	139,480	588	51,052	4,128	438,268	1,581	135,838
All other manufactures		2,518,646		4,176,868		8,506,364		8,356,430

SUMMARY.

Source.	1909	1910	1911	1912
	Pesos.	*Pesos.*	*Pesos.*	*Pesos.*
United States	1,637,096	3,940,980	7,819,122	8,501,554
All other countries	2,228,968	2,670,410	3,955,332	3,561,652
Total	3,866,064	6,611,390	11,774,454	12,063,206

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COAL MINING IN 1912

By F. A. DALBURG

The year 1912, as recorded in its production of coal, showed a great depression from 20,000 tons for 1911 to 2,720 tons for 1912. The cause for this decrease was that the mine of the East Batan Coal Company, the principal source of production, has been in the hands of a receiver since May, 1911, and was finally forced to close down. The assignee for the company worked unremittingly in an attempt to reorganize the corporation and secure funds for proper working of the mine. However, the upkeep of the mine was such a source of expense that it was finally sold at public auction to the Government of the Philippine Islands for the sum of 21,000 pesos, the amount of its preferred claim. Since August, 1912, all tracks and pumps have been removed from the mine, and it is now full of water. The primary cause for the failure of the East Batan Mine was insufficient development underground and too much expense on the surface plant. It is probable that the seam cannot again be mined from the old workings, but will have to be opened by an entirely new slope.

Another cause for the depression in the coal industry was the closing of the Camansi mine in Cebu due to the typhoon of October, 1912, which destroyed part of the railway and buildings. The mine has not been worked since that time.

At present, with the exception of some preliminary prospecting work, the coal-mining industry is at a standstill.

The failure of the mines at this time is decidedly inopportune. The Bureau of Science has just installed a 67-horsepower Otto gas-producer plant made by Gasmotoren Fabrick Deutz. The plant consists of a generator and a producer-gas engine with direct-coupled dynamo, and forms one of the regular power units of the Bureau of Science. The plant is being operated exclusively and regularly on Batan coal and uses this fuel successfully to furnish cheap power.

The Manila Gas Corporation expects to have its gas works completed in October. The annual capacity of the plant is to be 4,000,000 cubic meters of coal gas, and this output can be doubled at any time. Provision will also be made for producing water gas and for saving the by-products—ammonia, coke, and sul-

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PLATE IV. BRIQUETTES MADE OF PHILIPPINE COAL.

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phuric acid. Coking coal will have to be imported, but no doubt Philippine coal could be used for the generation of gas.

In Table I, the quantity and value of coal and coke imported into the Philippine Islands since 1909 are given.

In Table II, the total production since 1842 is shown.

TABLE I.—*Coal and coke imported into the Philippine Islands, 1909 to 1912.*

COAL (SUBJECT TO DUTY).

Country.	1909[a]		1910[a]		1911[a]		1912[a]	
	Weight.	Value.	Weight.	Value.	Weight.	Value.	Weight.	Value.
	M. tons.	*Pesos.*	*M. tons.*	*Pesos.*	*M. tons.*	*Pesos.*	*M. tons.*	*Pesos.*
China	43	260	110	1,216	1	6	6	40
East Indies:								
British	1,601	11,692	26,280	164,230	17,317	109,110	5,092	22,434
Dutch			1,295	8,676	8,617	37,750		
French	32	388						
Japan	293	2,114	101,603	823,114	166,426	1,303,592	299,874	1,588,606
Australia	171,866	908,476	178,755	947,546	233,175	1,144,330	124,816	616,776
Total	173,835	922,930	307,983	1,944,682	413,736	2,594,788	429,788	2,227,856

[a] Twelve months ending June 30.

COKE (SUBJECT TO DUTY).

	M. tons.	*Pesos.*	*M. tons.*	*Pesos.*	*M. tons.*	*Pesos.*	*M. tons.*	*Pesos.*
United States	59	734	4	144	160	4,386	250	4,936
United Kingdom	25	686			10	310	57	1,740
China			1	30	2	62	101	2,386
Hongkong	8	260	11	526	29	340	15	450
Japan	9	322	263	4,678	170	3,070	228	3,572
Australia	343	4,900	759	10,100	1,158	17,812	1,149	15,928
Total	444	6,902	1,038	15,138	1,529	26,644	1,800	29,012

COAL (FREE OF DUTY).

Importer.	1909[a]		1910[a]		1911[a]		1912[a]	
	Weight.	Value.	Weight.	Value.	Weight.	Value.	Weight.	Value.
	M. tons.	*Pesos.*	*M. tons.*	*Pesos.*	*M. tons.*	*Pesos.*	*M. tons.*	*Pesos.*
Manila Railroad Co	2,019	11,642	3,203	17,218	2,468	12,790	6,899	35,356
Philippine Railway Co.	8,292	42,154	12,307	81,944	8,123	47,374		
Insular Government	40,519	[b]243,114						
United States Government	173,781	[b]1,042,686	104,054	644,166	93,999	502,086	25	784
Total	224,611	1,339,596	119,564	743,328	104,590	562,230	6,924	36,140

[a] Twelve months ending June 30. [b] Estimated.

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TABLE I.—*Coal and coke imported, etc., 1909 to 1912*—Continued.

SUMMARY OF COAL CONSUMPTION OF THE PHILIPPINE ISLANDS.

	1909[a]		1910[a]		1911[a]		1912[a]	
	Weight.	Value.	Weight.	Value.	Weight.	Value.	Weight.	Value.
Imported:	*M. tons.*	*Pesos.*	*M. tons.*	*Pesos.*	*M. tons.*	*Pesos.*	*M. tons.*	*Pesos.*
Subject to duty	173,835	922,930	307,983	1,944,682	413,736	2,594,788	429,787	2,227,856
Free of duty	224,611	1,339,596	119,564	743,328	104,590	562,230	6,924	36,140
Produced in the Philippines	30,336	197,184	27,969	176,255	20,000	130,000	2,720	20,200
Total	428,782	2,459,710	455,516	2,864,265	548,326	3,287,018	439,431	2,284,196

[a] Twelve months ending June 30.

TABLE II.—*Coal production of the Philippine Islands from 1842 to 1912.*

Years.	Weight.	Value.
	M. tons.	*Pesos.*
1842-1906	[a]30,000	450,000
1907	4,123	26,800
1908	10,035	77,166
1909	30,336	197,184
1910	28,655	176,255
1911	20,000	130,000
1912	2,720	20,200

[a] Estimated.

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THE PRODUCTION OF NONMETALS IN 1912

By WALLACE E. PRATT

TABLE I.—*Comparative production of nonmetals in 1911 and 1912.*

Commodity.	1911	1912	Increase.		Decrease.	
			Amount.	Per cent.	Amount.	Per cent.
	Pesos.	*Pesos.*	*Pesos.*		*Pesos.*	
Coal	130,000	20,200			109,800	85
Clay products	450,000	453,000	3,000	0.7		
Lime	90,000	92,026	2,026	2.2		
Sand and gravel	477,344	468,750			8,594	1.8
Stone	655,795	651,049			4,746	0.8
Salt	550,000	574,511	24,511	4.5		
Mineral waters	60,000	55,849			4,151	6.9
Total	2,413,139	2,315,385			97,754	4.05

Owing principally to the recent inactivity in coal mining, the production of nonmetals in 1912 fell slightly below that for the preceding year.

Coal.—The principal coal mine in the Archipelago reports no production in 1912. This mine has been described in previous numbers of The Mineral Resources and its present condition is discussed on page 38.

The small production reported comes from the Island of Cebu. The Cebu coal is better than the average Philippine coal in quality, but has not been developed on a large scale. Exploratory work is in progress in the Uling district in Cebu, where a great deal of prospecting was done between 1860 and 1870. This locality was repeatedly pronounced by the eminent Spanish engineer, Don Enrique Abella y Casariego, to be the most promising in the Archipelago, and was made the subject of a special concession involving financial support by the Spanish Government just prior to the American occupation.

Clay products.—The household manufacture of earthenware and the native and Chinese industries which produce common brick, flower pots, and the large jars used in the native sugar industry and for general receptacles constitute the principal clay-working industries of the Philippines. Earlier numbers of The Mineral Resources have dealt extensively with these industries, and there is little to be added now. The character and quality of

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the output have remained practically the same, and no new producing centers are reported.

Research concerned with the manufacture of a better class of products, especially vitrified brick and structural materials, from Philippine clay has been continued in the Bureau of Science and the ceramic department of the School of Arts and Trades in Manila. The trade school each year sends out young Filipinos with a knowledge of clays and modern clay working, and the influence of these students should result ultimately in the improvement and extension of the native industry.

The Iwahig penal colony is manufacturing common brick for its own use and for sale according to the statement of the Director of the Bureau of Prisons. The native colonists carry out the work under white supervision. An alluvial clay obtained from the Maclacdao River in the central colony is used, and yields a red brick of fair quality. Carabaos are employed to drive a pug mill and molding machine and to haul clay to the mill and green brick to the single kiln. The kiln is fired about three times a month, and has a capacity of 25,000 bricks. The brick is valued at 20 pesos per thousand. Wood serves for fuel.

Aside from its use for pottery and brick, clay is employed in making a cold-water paint throughout the Islands.

Lime.—An increased demand for lime has arisen in connection with the operation of modern sugar mills erected during the past few years. Limestone from Montalban has been used in burning lime for a new mill at Muntinlupa, Rizal Province. The large mill at Mangarin, Mindoro, is burning lime from limestone obtained in the vicinity of Mangarin. Several new sugar centrals in Negros are including limekilns in the design of their plants. There is a great deal of limestone on the Island of Negros itself, but in the past much of the lime used in the sugar industry in Negros has been burned from limestone obtained on Guimaras Island, Iloilo Province. Lime for the Manila market is obtained mainly from sea shells gathered and burned along the adjacent shores of Manila Bay and in part from pure crystalline limestone which occurs about 6 kilometers northeast of Darangan, a barrio of Binangonan, Rizal. The production at Darangan was formerly much greater than it is at present. The limestone makes good lime, but in the native process of manufacture the product becomes partly slacked.

Formerly the burning centered at Darangan, but on account of the scarcity of wood for fuel the limestone is now burned at the quarry and the lime transported to Darangan. The native kiln consists of a circular hole in the ground with a fireplace dug

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out at one side. The holes are usually about 1.5 meters deep, varying in diameter from 1 to 4 meters. The kiln is continued above the ground about 1 meter by building up walls of limestone or earth around the perimeter of the hole. The kiln is charged with wood and limestone together, the wood being cut to short lengths and the limestone broken into pieces varying in weight up to 4 kilograms or more. The larger pieces are frequently not thoroughly calcined. The charge is covered with a layer of limestone, and the fire is started in the hearth. When the burning is complete, water is usually added to break up the larger pieces and to hasten the cooling of the kiln.

The total production at Darangan during the year 1912 was probably less than 20 metric tons of partly slacked lime, valued at 16.50 pesos per ton at Darangan. The lime is shipped in cascos, across Laguna de Bay and down the Pasig River, to Manila.

Sand and gravel.—On account of its proximity and consequent cheapness, sand from the Pasig River is used for most of the construction in Manila, although it is not entirely satisfactory in quality. Recently a company has been organized to take over the dredging rights along the Mariquina River (tributary to the Pasig) where a better sand will probably be obtained. An interesting feature of this enterprise is the intention of the operators to wash the sand in order to save a small gold content which it is said to contain.

During a recent inspection of Lubang Island which lies off the southwest coast of Luzon about 130 kilometers southwest of Manila, F. T. Eddingfield, of the Bureau of Science, noted extensive beaches of sharp, quartz sand along the coast. This sand is fairly pure quartz but contains a small proportion of clear feldspars and comminuted sea shells. The quartz comes from a quartz-bearing schist of which part of the island is made up. Lubang has a protected natural harbor which is readily accessible from Manila.

Sand and gravel are obtained from streams and seabeaches throughout the Islands. Several hundred thousand cubic meters of sand were dredged from Manila Bay during the past year to be used in filling in the area to be occupied by the new boulevard along the south water front. The cost of sand exclusive of transportation averages a little more than 30 centavos per cubic meter, while the corresponding cost of gravel is above 1 peso per cubic meter. Sand sells at 1 peso per cubic meter and gravel at 2 pesos per cubic meter in Manila.

Stone.—Stone is not much used for modern building construc-

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tion in the Philippines except in inland districts like parts of Mountain Province where the cost of cement is prohibitive. Limestone is used for the construction of public buildings in Mountain Province. The reported production outside of Mountain Province consists principally of rough stone used for the basal course of first-class roads. Hand mills for grinding corn are made of limestone and andesite by native workmen in many localities.

Imports of stone amounted to 35,424 pesos in 1912 according

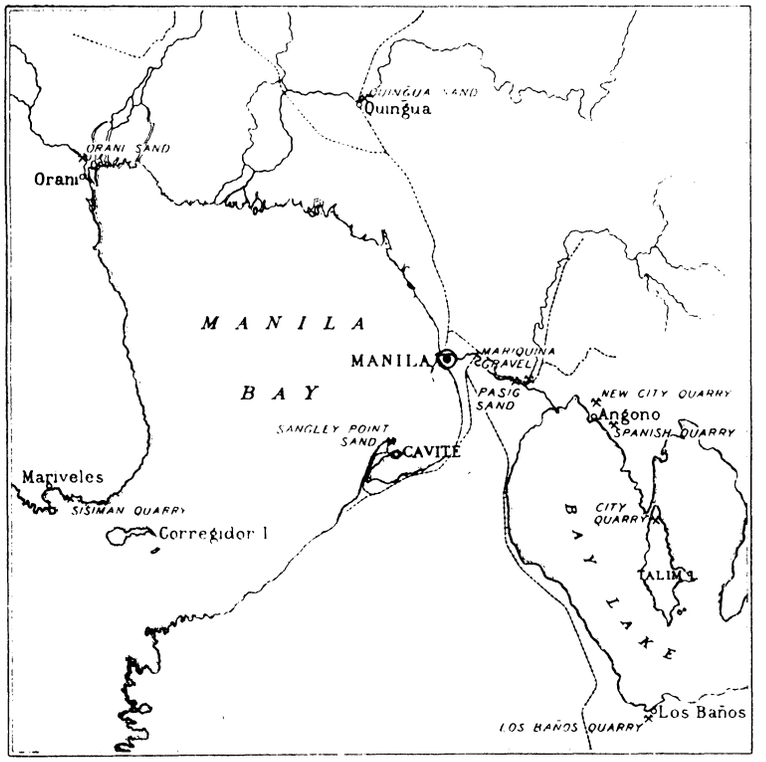

Fig. 4. Stone quarries and sand pits near Manila.

to the records of the Bureau of Customs, and included marble for decorative purposes, abrasives or whetstones, small grinding mills, and pebbles for tube mills. A fine-grained andesite or andesitic tuff from Japan is worked up into whetstones, and finds a ready sale in the Philippines.

Salt.—The extensive household industry of making salt from sea water, the manufacture of salt from the same source by the Chinese, and the evaporation of smaller quantities of salt from

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saline spring waters was described at length in The Mineral Resources for 1911. A normal increase in the local production is reported for 1912. The imports of salt for 1912 amounted to 42,144 pesos at a value of 14.8 centavos per kilogram. The greater part of the salt imported is fine table salt.

Cement.—The investigation of local cement resources has been continued by the Bureau of Science and by private capital during the past year. Materials collected at several of the favorable manufacturing sites recorded in the last preceding number of The Mineral Resources have been burned to satisfactory cements in the division of general, inorganic, and physical chemistry of the Bureau of Science. At least two groups of capitalists are considering the proposition of local cement manufacture, and it is very probable that a plant will be erected ultimately at one of the suggested locations.

Cement imports were smaller in the calendar year of 1912 than in 1911 as shown by the records of the Bureau of Customs. During the fiscal year 1913 (July 1, 1912, to June 30, 1913), cement to the value of 1,382,200 pesos was imported, while in the fiscal year 1912 the imports were only 1,079,498 pesos. The imports of Portland cement amounted to 317,769 barrels valued at 1,139,374 pesos during the calendar year 1910, 383,590 barrels valued at 1,260,792 pesos in 1911, and 346,070 barrels valued at 1,036,456 pesos in 1912. These are invoice values on board ship exclusive of import duty, and are lower than values given in former numbers of The Mineral Resources, which were based on the prevailing market prices of cement in Manila.

The import duty on Portland cement is assessed on the weight of cement and immediate container, at the rate of 32 centavos per 100 kilograms, and amounts to about 58 centavos per barrel. The Bureau of Supply, purchasing cement in large quantities for Government use, paid 4.39 pesos per barrel on the semiannual contract for the first half of the year 1912, and 4.64 pesos per barrel on the contract for the last half of that year. These contracts were awarded to local importers who were obliged to pay import duty and to deliver the cement on the river front in Manila. At about the same time (latter part of 1912) cement was sold on the general market in Hongkong and Shanghai, China, and Tokyo, Japan, at prices equivalent to 4.40, 4.30, and 4.20 pesos, respectively.

Although the principal imports continue to come from Hongkong and French Indo China, the proportion of European cement imported has increased very rapidly during the past three years, having amounted to less than 7 per cent of the total quantity

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imported in 1910, 10 per cent in 1911, and 28 per cent in 1912. In the same period imports from the United States fell from 26 per cent of the total quantity in 1910 to a small fraction of 1 per cent in 1912. Imports from the countries in the Far East have ranged from more than 85 per cent of the total quantity in former years to 66 per cent in 1910. In 1912 they amounted to about 72 per cent of the total importation. It appears from these figures that manufacturers in the United States have lost interest in the Philippine market and that plants in the Orient have not kept out European competition. The capacity of any one of several oriental plants is greater than the total Philippine consumption. The explanation is that the demand for cement in the Orient generally is so great and prices are so high outside the Philippines that the manufacturers in China, Japan, etc., find it more profitable to sell their product locally than to export to the Philippines. Thus, it may be deduced that a local plant, if established, would not have to contend with a permanent lowering of selling prices by other plants in the Far East unless the general market conditions change.

Petroleum.—Interest in the petroleum field on Bondoc Peninsula continues unabated, but no further drilling exploration has been undertaken. This district has three shallow wells, two on the Bahay River (depths 40 and 100 meters, respectively) and one on the Vigo River (depth 21 meters). All three wells encountered oil in small quantities. For a fuller report, see page 49.

The known oil seeps in Cebu (Toledo and Alegria on the east coast) are under the control of a local business firm, Messrs. Smith, Bell & Co., but, excepting the two wells drilled at Toledo before the American occupation, no development has been attempted.

Traces of oil on the Island of Palawan were reported recently, but the exact situation of the seeps is unknown. Likewise, reports of oil in the northern part of Leyte have been received without more detailed information. Messrs. Smith, Bell & Co. undertook to investigate reported occurrences of petroleum in northern Leyte in 1896, but the insurrection of that year put an end to the work before it was completed. Their engineer stated that he found petroleum in clay or shale, but had no opportunity for a thorough examination. Petroleum seeps are indicated on Spanish maps between the towns of Villaba and San Isidro on the northwest coast of Leyte.

Several samples of gilsonite, a mineral pitch, have been

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submitted to the Bureau of Science recently. This material also comes from the northern part of the Island of Leyte near the town of Leyte. The gilsonite occurs in a bed about 1 meter thick, the outcrop of which is exposed for 6 meters along a small stream, according to the statement of the prospector, and is overlain by sandstone in a series of strata made up principally of blue shale or clay.

A well drilled in search of water at Janiuay, Iloilo, where petroleum and natural gas have been reported in the past, encountered a small flow of natural gas with salt water in a bed of sand and gravel at a depth of 542 meters. Small films of oil come up on the water with the gas, but may represent lubricants from joints of the steel well casing. Gas issues from the well constantly but without violence, accompanied by intermittent flows of salt water. A sample of the gas collected and analyzed by the Bureau of Science showed the following composition.

	Per cent.
Hydrogen	5.2
Methane	89.4
Ethane	0.0
Carbon dioxide	0.6
Nitrogen	4.3
Oxygen	0.0
Carbon monoxide	0.5

The Janiuay well penetrates a sedimentary series—clay, shale, and coarse sand. A well drilled recently at Oas, Albay, encountered inflammable gas at a depth of 120 meters. Oas is situated in an extensive area of alluvium, and the gas in this well is probably marsh gas from plant remains in the buried alluvium. Wells in alluvial deposits at various places have encountered small flows of inflammable gas which are believed to be marsh gas.

Miscellaneous nonmetals.—Local business men plan to exploit some of the numerous small deposits of bat guano which occur in limestone caves throughout the Philippines, and to investigate some of the known sulphur deposits with a view to the local manufacture of sulphuric acid.

In an attempt to perfect a roofing material which may be used in place of the common native roofing material, nipa, and be fireproof at the same time, asbestos from the Ilocos Norte asbestos deposits [1] has been employed in combination with other substances. The initial experiments were made with the idea of winning the prize of 15,000 pesos which the Government offers for a suitable substitute for nipa. The satisfactory results

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obtained by the inventors using asbestos led them to withdraw from the prize competition, which requires the surrender to the Government of the process for making the successful substitute, and to undertake the commercial manufacture of their roofing material. If these plans carry, a market may develop for the Ilocos Norte asbestos which has not been exploited to date.

Lithographic stone from near Angat continues to be used in small quantity for the rough lithographs appearing on cigarette packages and similar paper wrappers for other articles manufactured in Manila. Mr. Nable, a Filipino engineer, was instrumental in starting this enterprise.

[1] Asbestos and manganese deposits of Ilocos Norte, by Warren D. Smith, *Phil. Journ. Sci., Sec. A.* (1907), 2, 145.

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PETROLEUM ON BONDOC PENINSULA, TAYABAS PROVINCE, PHILIPPINES [1]

By WALLACE E. PRATT and WARREN D. SMITH

History and development.—The existence of petroleum seeps on Bondoc Peninsula became generally known soon after the American occupation of the Philippines, although no mention of petroleum in Tayabas appears in the geological and mining publications of the former Spanish Government. Within the past few years a number of companies have been organized and claims have been located far and wide throughout the region, but development has not gone further than the drilling of two shallow wells. Each of these encountered oil, but neither yields a quantity great enough to class it as successful. However, the wells are close together, and neither is more than 100 meters deep. The region in which they are located might be made to yield oil in commercial quantities under proper treatment, although it probably could not be considered the most favorable from a geological standpoint. That the wells were not successful, therefore, fails as evidence upon which to condemn the whole field.

Literature.—Published description of Bondoc Peninsula is meager; George F. Richmond [2] investigated the physical and chemical properties of samples of the petroleum. A short paper on the geology of the field containing two diagrammatic cross sections of the structure was published by F. T. Eddingfield.[3]

[1] The statement made by the undersigned in an article in a local semi-technical journal in 1907 that "from a geological examination of these two fields (Cebu) and from what data I can get on the Tayabas country, I should not expect that any of these fields would support more than half a dozen wells as there seems to be no great structural reservoirs for the accumulation of any great quantity of petroleum," needs some explanation and modification.

The use of the words "half a dozen wells" was intended to include only wells yielding a considerable flow of oil and not the numerous barrel-a-day wells that might be tapped, and which exist in every oil field. There are said to be 600 wells in Formosa and yet the industry there scarcely pays.

The reference to Tayabas was not justified in view of only second-hand information. Certainly I would not make that statement in view of what I now know of the district from personal examination.—W. D. SMITH.

[2] *Phil. Journ. Sci., Sec. A* (1910), 5, 1.

[3] *Min. Resources P. I. for 1910, Bur. Sci., Div. Min.* (1911), 64.

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A general geological reconnaissance by Geo. I. Adams and Wallace E. Pratt [4] contains a reference to Bondoc Peninsula.

Situation.—The Tayabas oil field includes the southern half of a distinctly peninsular area which extends with regular, parallel coast lines to the south-southeast from the southern part of the mainland of Luzon. A constant width of about 17 kilometers persists throughout the southern portion of the peninsula to the very end, and, since petroleum seeps are known on both the east and the west coasts, the oil field assumes a rectangular outline, 17 kilometers wide by 50 kilometers long.

Catanauan and Mulanay, the principal coast towns in the southern part of the peninsula, are about 300 kilometers distant from Manila by steamship line. Inland from these towns only rough trails serve for transportation. Away from the coast, population is sparse and the country is unimproved. Occasional herds of cattle are encountered over the great stretches of alternating wooded and open country.

GEOLOGY

Physiography.—The contour of the peninsula, the character of the land forms, and the alignment of the drainage all reflect strongly the geology and the structure of the region. Over the southern half of the oil field the land rises from the coast to a relatively high, generally level or rolling plateau with deeply incised narrow valleys trending south-southeast along the main watercourses. The general level of this high table-land is from 250 to 300 meters. The extreme heights are slightly above 400 meters, while the rivers cut down to an elevation of 100 meters within a short distance from their heads. Farther northward the general elevation is lower (100 meters), and the land forms are more mature.

The high areas occupy broad gentle synclines, while the ridges developed locally along the lateral coast lines represent the steep limbs of narrow, sharp anticlines which characterize the structure of the peninsula. The valleys in turn follow the crests of the anticlines even in the topographically young region to the south. This early translation of the water courses from their probable initial position along structural valleys to the crests of the adjacent anticlines finds some explanation in the character of the highest member of the geologic formation which is a thick-bedded to massive limestone. It is conceived that this naturally rigid upper limestone member would respond to flexing stresses

[4] *Phil. Journ. Sci., Sec. A* (1911), 6, 449.

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by breaking rather than bending, and that the resultant fractures and dislocation planes would develop to a far greater extent along the anticlines which have been already described as sharp and narrow, than in the relatively wide, gentle synclines. Run-off from this original limestone surface would accomplish its cutting action as much through solution as through erosion in any case, and the cracks and fractures would afford opportunity for rapid progress by solution along the anticlines and the consequent translation of the main streams to their axes.

Stratigraphy.—Table I is a tentative correlation of the stratigraphic column for Bondoc Peninsula.

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TABLE I.—*Provisional scheme of stratigraphy. Bondoc Peninsula, Tayabas.*

Period.	Formation.	Character.	Thickness.	Oil horizon.	Characteristic fossils.
			Meters.		
Recent	Alluvium	Clay, sand, and gravel	0 to 10		
Pleistocene	Littoral deposits and raised coral reefs.	Raised coral reefs, beaches, etc	0 to 15		*Trochus fenestratus, Cerithium nodulosum, Telescopium telescopium, Conus flavidus.*
Pliocene and upper Miocene.	Malumbang formation:				
	Upper limestone	Coralline to sandy	20 to 50		*Pyrula gigas, Lucina bacuensis, Cerithium* sp., *Solecurtus grandis* sp. nov.
	Cudiapi sandstone	Bedded, calcareous, yellow to brown in color, and locally concretionary.	50 to 150		*Spondylus imperialis, Operculina costata, Bulla ampulla, Pecten senatorius.*
	Lower limestone	Limestone with coarse quartz sand and pebbles.	0 to 15		
Middle and lower Miocene	Canguinsa[a] sandstone	Blue to gray, massive, clayey sandstone, calcareous sandstone and limestone.	50 to 150		Large Lepidocyclines, *Cycloclypeus communis.*
Unconformity	Mechanical discordance with possible erosion.				
Lower Miocene or Oligocene (?).	Vigo shale[a]	Sandstone with conglomerate phases	5 to 20		*Globigerina* and *Polystomella.*
		Bacau stage; massive bluish to brownish black shale, subordinate sandy zones.	50 to 100	+	
		Gray, yellow, and brown, thin-bedded shale, sandy shale, and sandstone.	[b] 1,450	+	
Eocene. Unconformity		Concealed or lacking			
?		Basal conglomerate over diorite			

[a] Volcanic agglomerate is found in the northeastern part of the field, occurring in three small outcrops. Two of these appear in the upper part of the Vigo shale and one in the base of the Canguinsan sandstone.

[b] Base not exposed.

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For the purposes of this general discussion, the younger formations require no description further than that contained in Table I. The constitution and thickness of each of the divisions vary, the characteristics of shallow-water deposition alone being persistent. They are above the horizon at which oil has been observed, and any accumulation of petroleum is probably independent of their presence. The Canguinsa sandstone, a compact impervious rock, is encountered immediately above the Vigo shale which gives off most of the oil which is to be seen in the district, and in this position it might serve as a confining roof for oil, but its function as such is probably unimportant, because the upper part of the shale itself is close grained and does not afford a reservoir from which petroleum would escape readily.

The volcanic agglomerate is limited in extension to the northeast corner of the petroleum-bearing area, and occurs in three small exposures only. It is composed of adesitic fragments in a scanty cement likewise andesitic and probably tuffaceous. Apparently, it is very similar to the andesitic agglomerates which occur in oil fields of both Japan and Sumatra. It is found in Tayabas at two horizons, one exposure being overlain by the Canguinsa sandstone and the other two appearing in the Vigo shale.

The principal evidence of the unconformity placed in the lower division of the Miocene period is a rather abrupt steepening in the inclination of the strata below the Canguinsa sandstone, relative to the overlying beds. A fine-grained conglomerate several meters in thickness at this horizon is bedded in conformity with the Vigo shale beneath it.

The petroleum seeps on Bondoc Peninsula are associated with the upper part of the Vigo shale, but are below the minor and irregular sandstones at the top of the series. Because of their relative importance and rather distinct character, the petroliferous strata, aggregating from 50 to 100 meters' thickness, are designated apart from the Vigo shale proper as the Bacau stage. The Bacau stage is generally fine-grained, bluish to brownish black in color, and locally shows little evidence of bedding planes. It is principally a compact, indurated clay with subordinate sandy and sandstone zones. Some of the beds are carbonaceous, but those which emit the strongest odor of petroleum contain little carbon. The fossil shells in the petroliferous shale are covered with a film of oil or grease, and appear upon fresh exposure to be remarkably well preserved. Any attempt to remove them, however, reveals a tendency to crumble similar to the effect

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produced upon limestone by calcination. Fresh surfaces in the shale itself appear to be greasy. The material weathers into concretion-like ellipsoidal pieces which break down further, through the splitting off of concentric layers, into small fragments with conchoidal surfaces.

The Vigo shale below the Bacau stage is characteristically thin bedded, and consists of alternate layers of fine-grained and sandy shale with minor sandstone beds. In spite of these evidences of changing conditions of deposition, the formation is extensive and uniform over large areas. The thin-bedded strata grade insensibly into the Bacau stage above, while their base is not exposed within the area under discussion. Occasional layers appear to be identical in character with the material in the Bacau stage, but more generally the beds are sandy and yellow to brown in color. An apparent thickness of at least 1,400 meters of Vigo shale is exposed in the limbs of the principal anticline in the field, and the sections do not include the base of the formation.

Structure.—Bondoc Peninsula is anticlinal in structure, but the arch is not accomplished in a single, simple fold. A principal, central anticline follows the axis of the peninsula, and may be traced for a distance equal to one-half the length of the oil field. Flanking the central anticline on either side is a minor fold marked by small anticlines occurring at intervals along a line roughly parallel to the axis of the main anticline. The central anticline and the line of anticlines along each coast are sharp flexures, while the intervening synclines are broad and shallow, so that although the peninsula as a whole is an anticlinorium in structure the greater proportion of the land mass is contained within synclines.

The central anticline is inclined to the east, and pitches to the south. The beds near the axis dip almost vertically in the eastern limb and at an angle of about 40° in the western limb. The eastern limbs of the anticlines along the eastern coast are similarly steep and are likewise more highly inclined than the western limbs, while along the western coast both limbs of the anticlines are flatter, with the western limbs steeper. Erosion has cut away the crest well down into the Vigo shale on the central anticline in the northern part of the region, while farther south only the upper beds of the Vigo are exposed, and at the extreme southern end of the peninsula, owing to the southerly plunge of the anticlinal axis, even these are intact. The minor anticlines are eroded less deeply than the central anticlines.

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OCCURRENCE OF PETROLEUM

The presence of petroleum on Bondoc Peninsula is indicated by seeps of gas and oil at widely separated points throughout the region. The seeps occur invariably near the crests of anticlinal folds and always at about the horizon of the Bacau stage of the Vigo shale. In several instances the oil oozes directly from the shale, and the sandstones in the petroliferous strata usually show less petroleum than the shale at the surface. However, there is reason to believe that below the surface the interbedded sandstone lenses, which have not been opened by erosion, would be found to contain oil. Gas unaccompanied by oil is emitted at a number of places. No discoloration of the strata by the escaping petroleum can be detected, but an odor of the light oil is noticeable in the neighborhood of a petroleum seep. The wells which have been drilled obtained their oil from the Bacau stage of the Vigo shale.

PHYSICAL PROPERTIES OF THE PETROLEUM

The first analyses of Tayabas petroleum made by Richmond showed so large a proportion of the fraction distilling below 150° C. that the authenticity of the sample was questioned. Later examination of samples collected independently by a representative of the division of mines of the Bureau of Science at one of the wells confirmed the first results and proved that the petroleum contained an unusually large percentage of light oils.

Tayabas petroleum is light brown to wine-red in color by transmitted light and blue by reflected light. It loses part of its more volatile constituents readily upon exposure, and because of this fact specific-gravity determinations on different samples have shown variation. One sample tested as low as 0.805 in specific gravity, while the heaviest recorded sample had a specific gravity of 0.845. A representative sample subjected to fractional distillation by Mr. E. R. Dovey, formerly a chemist of the Bureau of Science, gave the following results:

Composition of Tayabas crude petroleum.

Crude oil:		
Specific gravity, at 29° C		0.8323
Refractive index, at 30° C		1.4639
Gasoline (0–150° C.):		
By volume	per cent	30.4
Specific gravity, at 30° C		0.7692
Kerosene (150–300° C.):		
By volume	per cent	50.9
Specific gravity, at 28° C		0.8333
Flash point (open cup)		42° C.
Fire point		54° C.

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Composition of Tayabas crude petroleum—Continued.

Heavy oil (300–400° C.):		
By volume	per cent	15.1
Specific gravity, at 28° C		0.9061
Residue (above 400) by weight	per cent	3.6
Sulphur		Absent.

The lighter fractions of this oil proved to be levorotatory to the extent of 0° 55′. Richmond found 30 per cent of unsaturated hydrocarbons in the crude oil, 16 per cent in the gasoline fraction, and 24 per cent in the kerosene fraction. The same authority reports 8.1 per cent of paraffin in the crude oil.

ORIGIN OF THE PETROLEUM

There is some evidence that the shale in the Bacau stage of the Vigo shale is the source of the petroleum in this field. Numerous remains of *Globigerina* have been detected in the shale, and it is considered probable that petroleum may have originated from them. They are not present, however, in as great abundance as would seem to be demanded to account for even the limited quantity of petroleum in these beds, and it is possible that a lower horizon, probably in the unexposed portion of the Vigo shale, may be the real source of petroleum, which, having diffused upward, is now encountered in the Bacau stage.

The strata below the Bacau stage, so far as they are exposed, show evidence of petroleum only rarely. However, an oil with the character of the Tayabas product might leave little or no trace in the rocks of its passage through them. Shale from which petroleum can be observed to seep, for example, loses every indication of its petroliferous character after a short period of exposure to air. Hence it may be conceived that petroleum exists in the unexposed lower beds of the Vigo shale, from which small quantities have migrated along favorable channels to the surface, where the oil has been completely dissipated from all the rocks except those which, like the close-grained shale in the Bacau stage, are of a character suited to retain it most tenaciously.

From the well-known principles of fractionation by diffusion through a porous medium, the light, clarified nature of the oil might be taken to confirm the theory of migration.

ECONOMIC CONSIDERATIONS: POSSIBLE DEVELOPMENT

The existence of petroleum on Bondoc Peninsula is established, although the quantity which may be available is undetermined. If no petroleum exists other than the apparently small quantity which occurs in the Bacau stage of the Vigo shale, commercial production is not likely to become extensive. The shale itself is

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too fine grained and compact to yield a free flow of oil to wells. It is very probable that properly located wells would encounter intact lenses of the subordinate sandstone which is known to occur in the Bacau stage, and, although the proportion of oil in the shale itself at the surface is very low (less than 1 per cent by weight in one of the most petroliferous exposures) and is even lower in the sandstones at the outcrop, it is entirely reasonable that intercalated sandstones which have escaped erosion should be saturated with oil. From wells piercing these sandstone lenses a production would be expected, but, since the entire thickness of the Bacau stage is probably less than 100 meters on an average and by far the greater proportion of the strata is shale, the generation and accumulation of petroleum in this stage would be limited.

If, however, petroleum is found in the unexposed base of the Vigo shale, the prospect is brighter. The Vigo shale is an extensive formation affording the possibility of a larger quantity of petroleum than could be contained in the Bacau stage alone. Its character (alternating shale and sandstone) is favorable for the accumulation of any oil that may be present. Judging from the situation of oil seeps in Tayabas, relative to the structure, and from experience in the productive field of Moera Enim, Sumatra, where the geologic conditions, apparently, are very similar to the conditions in the Tayabas field, the petroleum would be expected to collect in the anticlines in conformity with the general law of anticlinal accumulation. If oil is present in the lower Vigo shale and has tended to collect in the anticlines, then the structure in parts of the peninsula must be considered very favorable (anticlines intact above the oil horizon) for the retention of the oil under conditions which would permit of commercial exploitation.

Under the circumstances, Bondoc Peninsula must be classed as an unproved oil field where there is a good chance of obtaining petroleum economically.

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SAND-LIME BRICK AND ARTIFICIAL SANDSTONES IN THE PHILIPPINES

By ALVIN J. COX, W. C. REIBLING, and F. D. REYES

In the Philippines, the varieties of stone which are known to be good for building and construction purposes are not very numerous, and it is unfortunate that, with the exception of a few deposits of volcanic tuff ("adobe" stone), those which exist are not conveniently located for use. In the past, most of the permanent buildings were constructed of volcanic tuff, and its low and uncertain strength [1] made very massive construction work necessary. Moreover, as the stones have a dirty color and are only roughly shaped by hand into rectangular blocks 18 by 18 by 50 centimeters in size, they give structures a very unclean, irregular, and aged appearance.

Recently, important structures have been built almost exclusively of reënforced concrete, and concrete blocks have been used for small buildings. The high cost of cement and good aggregate makes such work expensive, but in spite of this and the great need of a cheap and durable building stone the sand-lime brick industry has not been introduced into these Islands in any form.

The Bureau of Science is carrying on a thorough investigation to ascertain the suitability and relative efficiency of available raw materials for the manufacture of sand-lime bricks and to study some of the most important technical considerations involved. This work is far from complete, but owing to numerous requests for data on the subject the publication of preliminary notes seemed advisable, and especially so in as much as they lead to very definite conclusions relative to the commercial value and feasibility of this industry in the Philippines.

USES FOR SAND BRICK AND ARTIFICIAL STONE

Good sand-lime bricks are sanitary, their hygroscopic properties are very slight (about 1.5 per cent in air), they absorb very little water when wet (6 to 10 per cent), do not effloresce, and in every way apparently meet the demands of tropical climatic conditions as a desirable structural material. We have considered principally the application of these processes to the manufacture of ordinary building stone. Fortunately, there are other uses to which either the reconstructed stone or the sand-lime process can be applied; namely, the manufacture of building blocks, sills, caps, fence posts, slabs, tiles, wall copings, templates,

[1] Cox, Alvin J., *Phil. Journ. Sci., Sec. A* (1908), 3, 191.

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jambs, lintels, steps, landings, curbstones, pipes, sidewalk slabs, and ornamental work such as elaborate moldings, monuments, flower pots, posts, vases, statuary, garden seats, and artificial marble.

There is a good local demand for such articles, and a plant equipped to manufacture these as well as the ordinary building stone has an opportunity successfully to establish a good and growing business; and especially so if, as can be easily accomplished, the bricks are manufactured so as to produce, when properly laid, broken and bonded horizontal as well as vertical joints [2] and building stones made similar to hollow interlocking and reënforcible concrete blocks now in use.

RAW MATERIALS

Sand brick or reconstructed stone can be manufactured on a commercial basis with either calcium carbonate or calcium hydrosilicate as the binding material. The former has for its advantage a minimum fuel consumption, while the latter withstands best the effects of fire and, in all probability, atmospheric and chemical influences. The calcium-carbonate process is not dependent upon the chemical composition of a sand or stone, but silica in a suitable chemical or physical condition is essential to the steaming process. With the notation of these differences, further consideration will be limited to the calcium hydrosilicate, the so-called sand-lime-brick process.

Generally speaking, common siliceous sand is the most desirable and the cheapest source of silica for this industry. A fairly good sand-lime brick can be obtained with almost any sand, but economy in manufacture limits the physical and chemical properties rather sharply.

Quarry débris, soft stone, and volcanic tuff are often suitable sources of silica and in many instances are capable of being crushed into desirable sand at no greater cost than that required for the installation of the division method. Siliceous sands, soft sandstone, and volcanic tuff are plentifully distributed throughout the Philippine Islands.

Richly colored siliceous materials naturally give bricks of a similar color, but otherwise a pleasing white to gray is obtained which is more or less spotted according to the color, quantity, and shape of the coarse grains. The color is permanent, unless oxidizable mineral pigments such as iron are present.

Lime.—In ordinary lime mortar, magnesia is not considered detrimental, but it cannot be substituted for calcium oxide in the

[2] Strale, A. N. H., Pat. No. 1,021,851, April 2, 1912.

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sand-lime-brick industry on account of its slow slaking properties. Other impurities in the limestone such as sand, clay, and iron oxide should also be avoided. They tend to produce slow slaking, fluxed and overburned lime,[3] as well as to decrease the efficiency by dilution. On the other hand, a comparatively pure calcite limestone gives the best results, and can be burned and slaked with the least expense and difficulty. It is absolutely necessary that the free lime be thoroughly hydrated before the bricks are molded; otherwise, the expansion due to subsequent hydration is very apt to cause the bricks to swell or crack and split.

The only first-class lime which can be purchased in the local markets is that which has been imported from Hongkong or other foreign ports.[4] The prospective manufacturer should burn his own lime and supply as well the demand for this material throughout the Islands.

LABORATORY METHODS

In testing the siliceous materials, the following general method of making sand-lime brick was used. When necessary, the sand or crushed stone was dried in the air and ground to almost its final degree of pulverization. Then 10 per cent by weight of dry, pulverized, hydrated Montalban lime was ground with part of the siliceous material, and the whole thoroughly mixed before and after the addition of water. The mixture was then molded into bricks under pressure as indicated in the tables, and finally the bricks were subjected to the action of live steam at a pressure of 125 pounds per square inch (8.79 kilograms per square centimeter) for from five and one-half to eight hours, as specified.

The first experiments were made to ascertain only the general adaptability of the available raw materials, and no attempt was made to secure better conditions and results than would have been obtained had the material been subjected to an ordinary commercial process for the manufacture of common brick. In fact, it was our desire to make the test a severe one, and for this reason the bricks were molded at the low pressure of 4,600 pounds per square inch or less, and steamed only five and one-half hours. Later, the materials were tested under more

[3] The evil effect of free lime and magnesia in sand-lime brick is in all respects similar to their effect in indurated Portland cement, and the slaking properties of free lime under all conditions of burning, grinding, and seasoning are important considerations. *Cf.* Reibling, W. C., and Reyes, F. D., *Phil. Journ. Sci., Sec. A* (1910), **5**, 117–142; (1911), **6**, 207–252; (1912), **7**, 135–191.

[4] Recent imports of slaked lime from Hongkong showed a purity of about 85 per cent.

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favorable conditions in order to ascertain their fitness for the manufacture of face brick, tiles, ornamental stonework, fire brick, etc. We have not had sufficient time to make a detailed study of each material such as would enable us to subject each to ideal conditions of manufacture, and the results obtained and recorded throughout this paper can be, and in many instances have been, improved by more thorough mixing, better granularimetric composition, and a higher molding pressure.

RAW MATERIALS IN THE VICINITY OF MANILA

The high cost of land transportation throughout the Philippine Islands makes the location of the factory with respect to the market and raw materials a consideration of more than usual importance. Eventually, sand-lime-brick factories should be installed at all of the principal commercial centers of the Archipelago where suitable raw materials are available in order to reduce the necessary transportation to a minimum. For several years to come the demand in the Philippines will probably not be great enough to support more than one, or, possibly, two sand-lime-brick plants; and, since Manila appears to be the most desirable location for the first plant, the near-by raw materials have been given primary consideration.

Limestone.—The most available and important calcareous raw materials in the vicinity of Manila are two exposures of Miocene limestone, one near Montalban about 30 kilometers from Manila, on a line of the Manila Railroad Company, and the other in a semimountainous country about 7 kilometers north of Binangonan, Rizal Province, and about 20 kilometers from Manila. The analyses given in Table I show that they are almost pure calcium carbonate.

TABLE I.—*Ultimate chemical composition of Binangonan and Montalban limestones.*

Constituent.	Limestone from Binangonan.	Limestone from Montalban.[a]
	Per cent.	*Per cent.*
Water at 110° C	0.16	0.25
Silica (SiO_2)	1.12	0.94
Iron and aluminum oxides (R_2O_3)	0.15	1.14
Calcium oxide (CaO)	53.78	54.61
Magnesia (MgO)	1.19	0.22
Combined alkalies ($K_2O + Na_2O$)	0.77	0.56
Sulphuric anhydride (SO_3)	trace	trace
Loss by ignition	43.15	42.79
Lime calculated to calcium carbonate ($CaCO_3$)	96.03	97.52

[a] Analyzed by Forest B. Beyer.

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Binangonan limestone is the more available to Manila. Water transportation from Montalban to Manila is more difficult, and railroad transportation is expensive. In either place there is an abundant supply of almost pure limestone within 30 kilometers of Manila.

The siliceous materials in the vicinity of Manila vary greatly in chemical and physical properties, but after careful consideration we were able to select 8, so that the variety included the principal characteristics of all of probable importance. Their character and usefulness will be discussed in conjunction with their location.

Beach sand.—South of Manila there is no stream entering the bay which contains deposits of sand. Between 12 and 14 kilometers from Manila at Sangley Point and at Las Piñas, with which there is water communication, beach sand is abundant. This sand is derived principally from basaltic rocks which occur fragmentally in the tuff formation which borders Manila Bay. The grains are in an advanced stage of decomposition and are easily crushed. The Manila beach itself at Maytubig has similar, but very fine, sand from which fairly good sand-lime bricks have been made experimentally. The efficiency of this fine beach sand is of more than ordinary importance because it is the only available siliceous material which is fine enough to require no grinding and also because material of this class is so abundant and easily procured.

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TABLE II.—*Maytubig beach sand and its efficiency as a sand-lime-brick material.*

CHARACTERISTIC GRANULARIMETRIC COMPOSITION.

Standard sieve No	10	20	30	40	50	60	80	100	200
Meshes per linear inch	10	20	30	40	50	60	80	100	200
Diameter of openings in millimeters	1.85	0.92	0.56	0.47	0.34	0.28	0.20	0.15	0.06
Percentage of sand passing through specified sieves	100.0	100.0	99.9	99.9	98.0	96.5	80.4	51.7	6.0

THE SAND-LIME BRICK.

Mixture No.	Fineness of sand as used.	Dimensions of brick.	Area of bearing surface.	Duration of steam treatment.	Molding pressure per square inch.	Compressive strength. Total.	Compressive strength. Per square inch.
		Inches.	*Sq. in.*	*Hours.*	*Pounds.*	*Pounds.*	*Pounds.*
1	As received	2 × 2 · 2	4.0	5.5	4,600	7,200	1,800
2	One-fourth pulverized	2 × 2 · 2	4.0	5.5	4,600	7,720	1,930
1	As received	2 × 2 × 2	4.0	8.0	10,640	13,880	3,470
2	One-fourth pulverized	2 · 2 × 2	4.0	8.0	10,640	11,200	2,800
3	One-tenth pulverized	3 · 3 · 2.25	6.75	8.0	10,000	20,560	3,200
3	do	3 × 3 · 2.25	6.75	8.0	15,000	25,920	3,840
4	As received	2 × 2 · 2	4.0	8.0	7,640	8,000	2,000
4	do	2 · 2 · 2	4.0	8.0	10,000	13,360	3,340

Mixture No.	Molding pressure in pounds per square inch.	Density. Air dry.	Density. Dried at 110°.	Absorption after 24 hours in water. Air dry.	Absorption after 24 hours in water. Dried at 110°.
4	10,000	2.08	2.01	7.40	11.0

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In all instances, the bricks had a pleasing steel-gray color which after several months' exposure to sun and rain had not changed, but the surface would not take a good polish.

Pasig sand.—Most of the sand used in Manila is dredged or dipped up in baskets from the Pasig and its principal tributary, the Mariquina River. A good sand-lime brick can be made with this sand, but the supply is rapidly decreasing owing to the great quantity used for concrete construction work.

TABLE III.—*Pasig sand and its efficiency as a sand-lime-brick material.*

GRANULARIMETRIC COMPOSITION.

Sieve No		10	20	30	40	50	60	80	100	200
Per cent of sand passing through specified sieves.	[a]	99.5	99.0	95.0	71.0	36.0	20.5	10.0	2.0	trace
	[b]	96.0	64.0	42.0	38.0	23.5	10.0	5.0	2.6	trace

THE SAND-LIME BRICK.

Mixture No.	Degree of pulverization in per cent through specified sieves.					Duration of steam treatment.	Molding pressure per square inch.	Compressive strength.	
	No. 20.	No. 40.	No. 80.	No. 100.	No. 200.			Total.	Per square inch.
						Hours.	*Pounds.*	*Pounds.*	*Pounds.*
5	100.0	84.0	55.4	46.5	18.6	5.5	2,300	5,980	1,495
5	100.0	84.0	55.4	46.5	18.6	5.5	4,600	10,800	2,700
6	89.4	57.7	23.7	16.5	11.7	8.0	7,640	12,720	3,180
6	89.4	57.7	23.7	16.5	11.7	8.0	10,000	13,640	3,410
[a]7	91.6	65.8	33.7	24.7	13.2	8.0	7,640	17,000	4,250
7	91.6	65.8	33.7	24.7	13.2	8.0	10,000	21,280	5,320
8	99.6	72.9	40.4	37.4	20.0	8.0	7,640	19,040	4,760
8	99.6	72.9	40.4	37.4	20.0	8.0	10,000	23,740	5,935

Mixture No.	Molding pressure in pounds per square inch.	Density.		Absorption after 24 hours in water.	
		Air dry.	Dried at 110°.	Air dry.	Dried at 110°.
7	7,640	2.24	2.15	6.1	10.5
7	10,000	2.28	2.19	4.3	9.7
[c]8	7,640	2.23	2.13	5.2	10.1
8	10,000	2.30	2.17	3.6	9.4

[a] Dipped up in baskets. [b] Gravel screenings from dredges. [c] Ground finer than No. 6.

Strong and dense sand-lime bricks are much more readily obtained with Pasig than with beach sand, and this is especially true when the molding pressure is low. The color of the product is darker and less pleasing, but the bricks made took a fairly good polish, due largely to the presence in quantity of large grains of andesite and basalt rock, as is shown by the granularimetric analysis of mixture 6.

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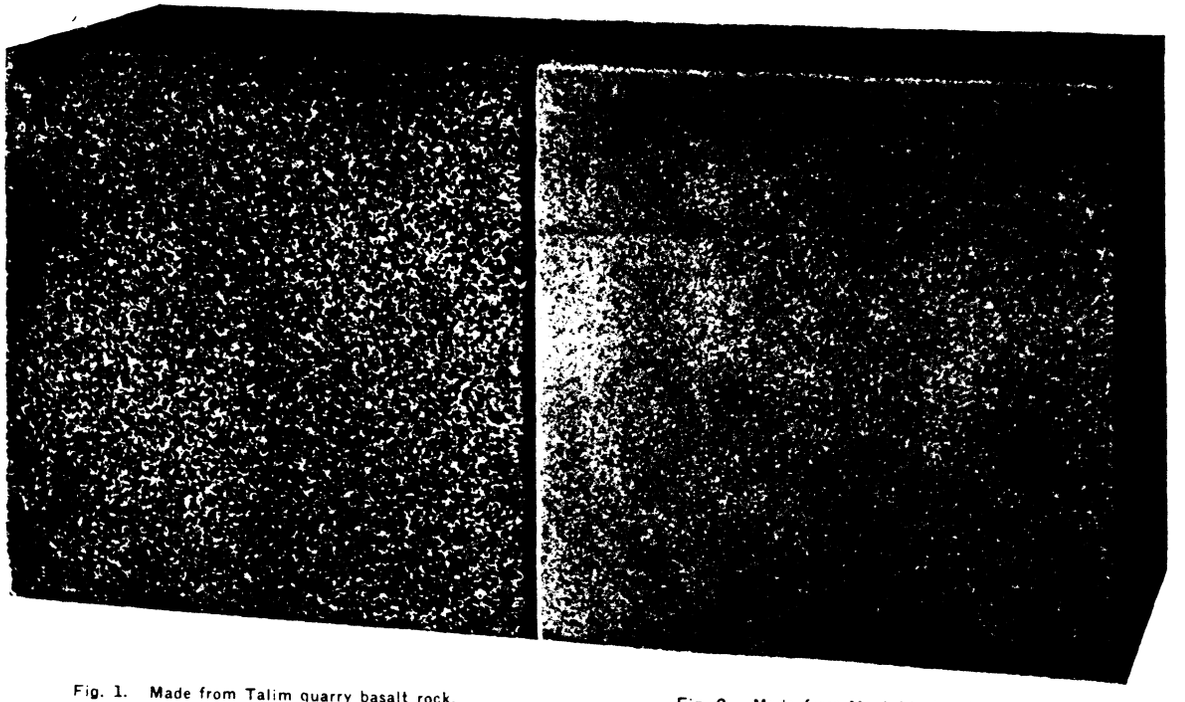

Fig. 1. Made from Talim quarry basalt rock.

Fig. 2. Made from Maytubig beach sand.

PLATE V. SAND-LIME BRICK.

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The granularimetric analyses of mixtures 6, 7, and 8 show a graduated increase in the degree of pulverization and a corresponding increase in strength. A comparison of the granularimetric analysis of the sand as used in mixture 8, with that of the sand as it is received, shows that considerable grinding is necessary in order to obtain great strength. However, we have a large quantity of very fine beach sand near at hand, and grinding expenses can be reduced to a low figure by mixing this with coarser available siliceous materials. The lower initial cost of beach sand would also make the production more economical. The results given in Table IV, for an equal mixture of Pasig and beach sand, were obtained without grinding the siliceous materials at all. A still better product would have been obtained had the beach sand been ground a little before mixing.

TABLE IV.—*Sand-lime bricks made with equal parts of Pasig and beach sand.*

Mixture No.	Granularimetric composition of mixed sands in per cent passing through the specified sieves.					Duration of steam treatment.	Molding pressure per square inch.	Compressive strength.	
	No. 20.	No. 40.	No. 80.	No. 100.	No. 200.			Total.	Per square inch.
						Hours.	*Pounds.*	*Pounds.*	*Pounds.*
9	99.8	75.7	54.8	27.2	3.2	8.0	7,640	10,720	2,680
9	99.8	75.7	54.8	27.2	3.2	8.0	10,000	13,760	3,440

Mixture No.	Molding pressure in pounds per square inch.	Density.		Absorption after 24 hours in water.	
		Air dry.	Dried at 110°.	Air dry.	Dried at 110°.
9	7,640	2.14	2.08	7.7	10.5
9	10,000	2.16	2.10	6.5	9.2

Quingua sand.—North of Manila, the Quingua River contains an important amount of pebble sand which is similar to Pasig sand, except that the grains are harder and the quartz a little more abundant. The distance from Manila is considerable (about 35 kilometers), and although transportation by water is possible the river is often too shallow for navigation by launches. Transportation by rail is possible, but the present rates are prohibitive. This sand has not been tested, but its similarity to Pasig sand and greater content of quartz make it certain that it is equally as good, if not better.

Tarlac sand.—Sand from the Tarlac River, at Tarlac, a station situated on the Manila and Dagupan Railroad, appears to be the best sand-lime-brick sand in Luzon. Owing to the large per-

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centage of quartz and clear glassy plagioclase feldspar, Tarlac sand-lime bricks have a pleasing grayish white color, and take a good polish with a sparkling, granitic appearance. So far as we have been able to ascertain, there need be no efflorescence even when the percentage of feldspar is as high as in this material. The best results in our simple tests of the fire-resistant properties of Philippine sand-lime bricks were obtained when Tarlac sand was used.

TABLE V.—*Tarlac sand and its efficiency as a sand-lime-brick material.*

GRANULARIMETRIC COMPOSITION.

Sieve No	10	20	30	40	50	60	80	100	200
Percentage of sand passing through specified sieves	98.5	74.0	41.0	22.0	11.5	6.5	3.5	1.5	0.5

THE SAND-LIME BRICK.

Mixture No.	Degree of pulverization in per cent through standard specified sieves.					Duration of steam treatment.	Molding pressure per square inch.	Compressive strength.	
	No. 20.	No. 40.	No. 80.	No. 100.	No. 200.			Total.	Per square inch.
						Hours.	*Pounds.*	*Pounds.*	*Pounds.*
10	100.0	85.0	71.0	59.0	20.0	5.5	2,300	7,000	1,750
10	100.0	85.0	71.0	59.0	20.0	5.5	4,600	10,060	2,515
11	89.3	24.6	18.3	17.7	10.7	8.0	7,640	13,040	3,260
11	89.3	24.6	18.3	17.7	10.7	8.0	10,000	13,640	3,410
12	99.9	60.5	33.8	26.5	20.5	8.0	7,640	13,880	3,470
12	99.9	60.5	33.8	26.5	20.5	8.0	10,000	15,920	3,980
[a]13	99.9	68.4	40.3	34.9	29.6	8.0	7,640	21,180	5,295
13	99.9	68.4	40.3	34.9	29.6	8.0	10,000	25,960	6,490

Mixture No.	Molding pressure in pounds per square inch.	Density.		Absorption after 24 hours in water.	
		Air dry.	Dried at 110°.	Air dry.	Dried at 110°.
12	7,640	2.19	2.11	3.8	7.5
12	10,000	2.24	2.17	2.4	5.7
13	7,640	2.22	2.16	2.1	5.0
13	10,000	2.29	2.23	1.7	4.1

[a] Ground finer than No. 12.

As with Pasig sand, the natural coarseness of Tarlac sand makes considerable grinding advisable; however, beach sand can be advantageously mixed with the more expensive sand. This, as well as the manner in which the strength of a given mixture may be affected by the quantity of water used, is shown in Table VI.

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TABLE VI.—*Sand-lime brick made with a mixture of equal parts of Tarlac and beach sand.*

Mixture No.	Degree of fineness in per cent through the specified sieves.					Percentage of water added to the raw materials.	Molding pressure per square inch.	Compressive strength.	
	No. 20.	No. 40.	No. 80.	No. 100.	No. 200.			Total.	Per square inch.
							Pounds.	*Pounds.*	*Pounds.*
[a] 14	95.7	62.1	49.4	33.7	8.4	8.0	7,640	7,920	1,980
14	95.7	62.1	49.4	33.7	8.4	8.0	10,000	13,360	3,340
[b] 15	95.7	62.1	49.4	33.7	8.4	15.0	7,640	14,040	3,510
15	95.7	62.1	49.4	33.7	8.4	15.0	10,000	16,620	4,155

Mixture. No.	Molding pressure in pounds per square inch.	Density.		Absorption after 24 hours in water.	
		Air dry.	Dried at 110°.	Air dry.	Dried at 110°.
15	7,640	2.11	2.09	6.5	7.7
15	10,000	2.19	2.14	4.9	7.5

[a] No water was pressed out during the molding of the first group.
[b] About 10 per cent of water was pressed out during the molding of the second group.

Orani sand.—At the mouth of the Orani River, about 55 kilometers northwest of Manila and directly across Manila Bay, there is an abundance of good sand which can be secured without dredging. The river can be entered by launches, and at low tide the sand can be loaded directly into barges and, without rehandling, towed to Manila. Orani sand is very similar to that from Tarlac except that it is less clean and its color is less attractive. Otherwise, it is as good as Tarlac sand for the manufacture of sand-lime bricks. We obtained a strength of 3,238 pounds per square inch with Orani sand when the molding pressure employed was only 4,600 pounds per square inch.

Volcanic tuff, unusually abundant in Bulacan and along the Pasig River, especially near Guadalupe, is another available source of siliceous material in the vicinity of Manila. It is a fragmental material which contains pieces of scoria, basaltic pebbles, and volcanic ash in varying and nonuniform proportions, and it is easily crushed. When mined, it is so soft that it can be quarried with an ax, but it hardens rapidly on exposure to the air. There are two grades of this water-laid tuff: (1) Coarse, containing numerous fragments of pumice and andesite; and (2) very fine, containing grains of pumice, feldspar, hornblende, and, at times, a little quartz. Our tests include Meycauayan, the best, and Guadalupe, the ordinary, volcanic tuff.

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TABLE VII.—*Volcanic tuff and its efficiency as a sand-lime-brick material.*

Mixture No.	Volcanic tuff used.	Degree of pulverization in per cent passing through the specified sieves.					Duration of steam pressure.	Molding pressure per square inch.	Compressive strength.	
		No. 20.	No. 40.	No. 80.	No. 100.	No. 200.			Total.	Per square inch.
							Hours.	*Pounds.*	*Pounds.*	*Pounds.*
16	Guadalupe	100.0	85.0	700	50.0	28.5	5.5	2,300	9,000	2,250
16	do	100.0	85.0	70.0	50.0	28.5	5.5	4,600	10,300	2,575
17	do	91.3	71.1	44.4	38.0	25.5	8.0	7,640	10,480	2,620
17	do	91.3	71.1	44.4	38.0	25.5	8.0	10,000	13,640	3,410
18	Meycauayan	68.5	44.9	28.4	23.5	13.0	8.0	7,640	12,440	3,110
18	do	68.5	44.9	28.4	23.5	13.0	8.0	10,000	12,960	3,240
19	do	70.5	48.3	31.2	26.0	17.8	8.0	7,640	18,140	4,535
19	do	70.5	48.3	31.2	26.0	17.8	8.0	10,000	20,140	5,035
20	do	83.3	61.2	38.2	32.5	20.2	8.0	7,640	20,720	5,180
20	do	83.3	61.2	38.2	32.5	20.2	8.0	10,000	22,080	5,520
21	Guadalupe	100.0	82.6	62.8	55.0	41.0	8.0	7,640	14,920	3,730
21	do	100.0	82.6	62.8	55.0	41.0	8.0	10,000	18,280	4,570

Mixture No.	Molding pressure in pounds per square inch.	Density.		Absorption after 24 hours in water.	
		Air dry.	Dried at 110°.	Air dry.	Dried at 110°.
20	7,640	1.87	1.75	6.0	13.4
20	10,000	1.89	1.77	5.9	13.0

A good polish could not be obtained, and, otherwise, the natural color was a rather unpleasing, dull, light brown.

A high content of soluble silica, such as is characteristic of these volcanic tuffs, favors the development of great strength. On the other hand, most of the individual grains are soft, and soft grains are detrimental to the strength. For best results the volcanic tuff should be mixed with hard-grained sands or crushed rock, and for this purpose it is especially adapted both on account of the high content of soluble silica and the ease with which it can be obtained, pulverized, and molded for a maximum strength.

TABLE VIII.—*Sand-lime brick made with a mixture of 1 part of pulverized Guadalupe stone and 3 of natural Pasig sand.*

Mixture No.	Degree of fineness in per cent through the specified sieves.					Duration of steam treatment.	Molding pressure per square inch.	Compressive strength.	
	No. 20.	No. 40.	No. 80.	No. 100.	No. 200.			Total.	Per square inch.
						Hours.	*Pounds.*	*Pounds.*	*Pounds.*
22	99.0	79.0	32.5	26.0	16.5	8.0	7,640	13,200	3,300
22	99.0	79.0	32.5	26.0	16.5	8.0	10,000	13,600	3,400

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The advisability of using volcanic tuff or beach sand in conjunction with other available siliceous materials rather than alone is further substantiated by the fact that the sand-lime bricks made from either alone possess the least density and absorb the most water.

Quarry débris is also available. The amount of rock and crushed stone used in Manila for breakwaters, macadam roads, and concrete is considerable, and at present 4 quarry sites are operated to meet the demand; namely, (1) the Rizal, (2) the Manila city quarries at Talim Island, (3) Carabao Island quarry in the south channel entrance of Manila Bay, and (4) the Sisiman quarry near Mariveles.

Crusher-run Sisiman stone contains a large amount of rock flour and sand which is not suitable for road surfacing on account of its poor cementive value. At present this quarry débris is a waste product. Sisiman rock is a gray andesite, while the stone in the other quarries is basalt. Neither contains free silica, but both are high in soluble silica. Owing to this high content of soluble silica and the hardness of the individual grains, sand-lime brick of the best quality can be manufactured from them. Both materials are especially suited for the manufacture of tiles and ornamental stonework.

TABLE IX.—*Sand-lime brick made from Sisiman-rock quarry débris.*

Mixture No.	Degree of pulverization in per cent passing through the standard specified sieves.					Duration of steam treatment.	Molding pressure per square inch.	Compressive strength.	
	No. 20.	No. 40.	No. 80.	No. 100.	No. 200.			Total.	Per square inch.
						Hours.	*Pounds.*	*Pounds.*	*Pounds.*
22	73.4	48.2	29.4	25.3	16.5	8.0	7,640	10,960	2,740
22	73.4	48.2	29.4	25.3	16.5	8.0	10,000	16,120	4,030

Mixture No.	Molding pressure in pounds per square inch.	Density.		Absorption after 24 hours in water.	
		Air dry.	Dried at 110°.	Air dry.	Dried at 110°.
23	10,000	2.22	2.15	4.4	7.5

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TABLE X.—*Sand-lime brick made from basalt-rock quarry débris.*

Mixture No.	Degree of pulverization in per cent passing through the standard specified sieves.					Duration of steam treatment.	Molding pressure per square inch.	Compressive strength.	
	No. 20.	No. 40.	No. 80.	No. 100.	No. 200.			Total.	Per square inch.
						Hours.	*Pounds.*	*Pounds.*	*Pounds.*
23	75.6	43.7	25.8	22.9	17.0	8.0	7,640	12,080	3,020
23	75.6	43.7	25.8	22.9	17.0	8.0	10,000	15,280	3,820

Mixture No.	Molding pressure in pounds per square inch.	Density.		Absorption after 24 hours in water.	
		Air dry.	Dried at 110°.	Air dry.	Dried at 110°.
23	10,000	2.34	2.28	3.8	6.1

Transportation from the Talim Island quarry, which is near Binangonan, involves only water transportation and costs under fairly economic administration about 1.15 pesos per cubic meter. At the present time the price of crushed stone from Talim is from 2.70 to 2.90 pesos per cubic meter at the Manila water front. Sisiman is directly across the bay, and, although about 55 kilometers from Manila, the cost of transportation should not be prohibitive as it would be entirely over deep water. At present, crushed stone from Sisiman costs 3.50 pesos at the Manila water front, but as the quarry débris is a waste product it should cost much less. These costs are so much higher than Pasig sand, which can be purchased for 97 centavos, or less, and the cheaper beach sand, that the manufacturer probably would care to use the crushed rock only for special purposes such as tiles and marble, for which it is especially adapted. However, the cost of production can be retained at a normal figure by mixing the quarry débris with beach sand or crushed volcanic tuff. The latter can be quarried at Guadalupe and transported to the Pasig River for about 43 centavos per cubic meter.

PLANT SITE IN MANILA

We believe that an economic scheme for utilizing the materials in the vicinity of Manila would be to locate a sand-lime-brick plant on the bank of the Pasig River adjacent to the volcanic tuff and bring limestone from Binangonan. This plan would avoid a long haul to the factory of supplies such as fuel, machinery, and operating necessities, and put the finished product in close communication with the railroads, and, by short water route, with the ships in the harbor, while close at hand would be the volcanic tuff and the sands from Pasig, Mariquina, Pasay, and Manila Bay.

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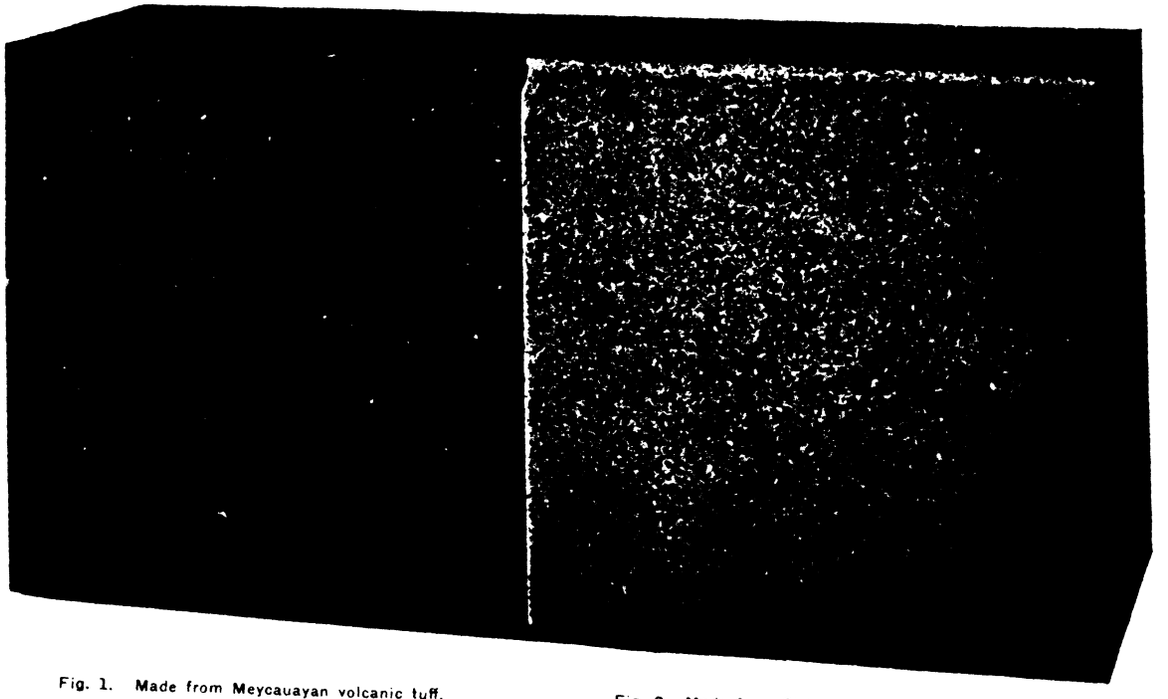

Fig. 1. Made from Meycauayan volcanic tuff.

Fig. 2. Made from Sisiman quarry andesite rock.

PLATE VI. SAND-LIME BRICK.

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OTHER PLANT SITES

Although at present Manila appears to be the most suitable place for a sand-lime-brick plant, other localities should be given thorough consideration. It is possible that the Visayan Islands and Mindanao will develop more rapidly than the rest of the Philippines, and the growing importance of Cebu, Iloilo, Zamboanga, and Jolo as ports may eventually make a central location more desirable than Manila.

FINANCIAL CONSIDERATIONS

In Germany the average cost of manufacturing common sand-lime brick is approximately 6 pesos (3 dollars United States currency) per thousand,[5] and in America the average cost is about 8 pesos for common and 9 pesos for face brick.

The cost of production can be maintained at a comparatively low figure in spite of rather unfavorable conditions. For estimates of costs and a detailed discussion, the reader is referred to a previous article by the present writers.[6]

SUMMARY

1. In the Philippines conditions are very favorable for the manufacture of brick and artificial stone from sand and lime if the enterprise is carefully and conservatively managed. The selection of a factory site, raw materials, process of manufacture, and machinery should receive unusual care.

2. The best location for the first plant is probably in the vicinity of Manila. Tests and information concerning the available raw materials indicate the advantages of locating a sand-lime-brick plant near the Pasig River at Guadalupe.

3. The cost of manufacturing and selling 20,000 9-inch bricks of the best quality is estimated not to exceed 13 pesos (6.50 dollars United States currency) per thousand. Compared with other Philippine building materials of equal value this is very reasonable, and the profit of a plant could be increased by extending its operations to include the manufacture of lime, hollow building blocks, tiles, slabs, marbles, ornamental stones, etc.

[5] Consul-General Skinner, *U. S. Daily Consular and Trade Reports*, Bureau of Manufactures (1911), No. 9.

[6] Cox, Reibling, and Reyes, *Phil. Journ. Sci., Sec. A.* (1912), 7, 317–353.

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CONTRIBUTION TO THE METALLOGENY OF THE PHILIPPINE ISLANDS[1]

By PAUL R. FANNING

DISTRIBUTION OF ORE DEPOSITS

The Philippine Islands represent part of a great ore belt which encircles the Pacific Ocean. This belt can be traced on the Asiatic side through the Malayan Archipelago, the Philippines, Formosa, and Japan. On the American side, the belt continues from Alaska through the western United States, Mexico, and South America. Everywhere, this ore belt follows lines of tectonic igneous activity.

The Philippine ore deposits are certainly Tertiary in age, probably Miocene. Not only on the basis of age, but of structure, mineralization, and associated rocks can this Archipelago be classed with some of the world's great mineral regions such as those found in Nevada, Idaho, Colorado, Mexico, Chile, and Peru.

Metallic ore deposits are dependent upon igneous activity for their origin, and as such activity has taken place in nearly all of the Philippine Islands we would expect a wide distribution of the metals. Such is the case, for quartz veins—bearing gold, copper, etc.—have been found in nearly every island of any size. The greater mineralized districts, such as Paracale, Masbate, Benguet, and Mancayan-Suyoc, center in and around areas apparently of maximum igneous activity. These areas are characterized by intrusive masses of volcanic rock.

Lindgren[2] has pointed out for the western United States the fact that "where the rocks lie horizontal and no disturbance has taken place ore deposits are rare, poor, or absent." In agreement with this, the distribution of ores in the Philippines shows a total absence throughout the undisturbed sedimentary and tuff areas. Lavas show no secondary metallic mineralization, except, as is true for the sedimentaries, tuffs, and agglomerates as well, in proximity to intrusives.

Ore belts.—A group of ore belts can be defined, extending through the Central Cordillera of northern Luzon, southward along Luzon, Marinduque, Masbate, Samar, Leyte, and the eastern half of Mindanao. This group may be divided into subsidiary belts which follow in trend and persistence the main cordilleras.

[1] The discussion in more detail will appear in The Philippine Journal of Science.

[2] The mining districts of the Western United States. *Bull. U. S. Geol. Surv.* (1912). No. 507, 7.

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These ore belts, like the tectonic lines "in general run north and south, but minor departures from this direction are to be seen in the lines running through the Islands of Palawan and Mindoro and those in the Sulu group, the Zamboanga Peninsula, and Cebu." [3]

It is important to note that this list of tectonic lines departing from the general trend by their northeast direction comprise the regions where the best gold is known. The major northwest or northern lines mark the gold belts rather than the minor northeast lines. In Aroroy, Masbate, where the two lines meet, valuable veins are found, the most important of which are parallel to the major northwest tectonic line. In general, there appears to be a relation between the greater tectonic features and the maximum ore deposition.

ORE DEPOSITS AND IGNEOUS ACTIVITY

For gold-mining districts in other parts of the world it has been shown clearly that the ore deposits are genetically related to igneous activity and this relation is fully demonstrated for the Philippines.[4] In all cases, the ore deposits occur in and around intrusive masses, and form the "metallic aureoles" so characteristic of mineral districts.

It is to be noted that great areas of extrusives occur which are devoid of deposits, and the surface nature of these volcanic flows logically has been unfavorable to ore formation. However, where lavas have been intruded by a later magma, as in certain portions of the Aroroy field, deposits in extrusives may be found. In such cases, the intruding magma has given the necessary conditions of temperature and pressure for the active work of fissuring and metallization.

In general, the ore deposits are associated with intrusion rather than extrusion, which indicates that maximum igneous activity is a factor in the formation of the ores.

The general magmatic sequence has been (1) basal andesites or diorites, (2) intrusion of quartz diorite or granite, (3) vein formation, and (4) later differentiations such as andesites and basalts. Intrusion has preceded and extrusion has followed the period of vein formation.

Rock types.—The type of intruding magma apparently has had an influence upon the formation of metalliferous areas. These

[3] Smith, W. D., *Phil. Journ. Sci., Sec. A* (1910), **5**, 308.

[4] Eveland, A. J., *Bull. P. I. Min. Bur.* (1905), No. 4, 53. Smith, W. D., and Eddingfield, F. T., *Phil. Journ. Sci., Sec. A* (1911), **6**, 429. Eddingfield, F. T., *ibid.* (1913), **8**, 81.

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areas have quartz diorites, andesites, or granites; that is, acid or intermediate types of rocks. This association is general throughout the Americas, in Japan, and in Formosa. The basic rocks such as basalts are almost universally barren of great gold deposits.

TYPES OF ORE DEPOSITS

The ore deposits belong nearly exclusively to the vein type. Contact-metamorphic and magmatic segregation deposits are rare or absent.

In most cases the veins are simple in structure, though brecciated veins, fracture zones, etc. are not unknown. Disseminations of pyrite in the wall rocks usually accompany the veins. Silicification and chloritization due to hydrothermal action are frequent.

VEIN PHASES

The veins may be divided into quartz and calcite phases, but every transition is known between these two extremes. In all districts the number of quartz veins is much greater than calcite. Pegmatite veins are rare or absent.

The quartz phase.—The quartz phase seems to represent the earlier period of vein formation during which the pressure and temperature were comparatively high.[5] It is believed that the mineral-bearing waters which produced the veins were direct emanations from the adjacent, cooling, intrusive magma.

The quartz phase may be divided into the gold-pyrite, the copper-gold-pyrite, and the lead-zinc-sulphide types. The types are believed to have resulted from cooling phases of the adjacent magma. There is some evidence to believe that the sequence has been (1) gold-pyrite veins, (2) copper-gold-pyrite veins, (3) lead-zinc-sulphide veins, (4) quartz-calcite veins, and (5) calcite (some quartz) veins.

In general, the quartz phase shows quartz gangue largely predominating over the sulphides, but in certain copper-gold types (Mancayan-Suyoc copper mines) and lead-zinc types (Marinduque etc.) the sulphides may predominate over the gangue. The gold occurs in three general phases: (1) Gold-bearing pyrite, chalcopyrite (or other copper sulphides), or galena; (2) primary free gold; (3) secondary free gold often associated with sulphides.

[5] There are not yet enough data to prove this. There is evidence, however, that there has been more than one period of ore deposition, so that what appears to be due to change of temperature or pressure or change of solution in a single period might in reality be due to the succession of different periods considerably separated in time.—W. D. SMITH.

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A distinct quartz phase appears to be shown by the occurrence of magnetite, hematite, pyrite, and chalcopyrite in some quartz veins of the Angat iron region. These veins possibly have formed under contact metamorphic condition of great heat and pressure.

The calcite phase.—One of the most interesting features of Philippine ore deposits is the occurrence of calcite veins in proximity to quartz veins. Unlike quartz, the data regarding calcite show no evidence that the calcite is a differentiation from a magma. We infer that the calcium has been leached from the cooling igneous rock by magmatic carbonic waters, and the occurrence of calcite veins is a last phase of the lowering temperature and pressure of the magma and surrounding rocks.

The field relation of calcite veins shows them generally to be later than the true quartz veins. This would be expected in consideration of such facts as the knowledge that calcite is one of the last minerals to crystallize from aqueous solutions. Calcite veins should characterize surface condition (little temperature and pressure), while the massive quartz veins should characterize the deeper zones of greater temperature and pressure. With a cooling magma, the focus of heat would recede downward, producing a downward progression of surface conditions. This would result in the formation of calcite veins in proximity to the quartz veins which formed during the earlier period of deeper seated conditions.

Fissuring.—The direction of fissuring in practically all districts is either parallel to the tectonic line passing through the region or is related to the intrusive mass of the immediate area. Thus, in Masbate, the major veins are parallel to the northwest tectonic line, while the minor set of veins are parallel to the southeast tectonic line. In Benguet the veins appear to be either parallel or radial to the intrusive mass, indicating a relation due to cooling. In addition, this area is near the so-called "central knot" of Luzon where the tectonic features are complex. This naturally should produce diverse direction of fissuring.

The structural and mineral characteristics of most Philippine veins indicate fissuring and vein formation under conditions of moderate depths. This is borne out by the type of rocks in which the veins are found. The calcite veins indicate rupture under considerable load, but mineralization under comparatively low temperatures. Some quartz veins show repeated reopening, indicating the continuance of strain. The chalcedonic nature of this later filling indicates deposition under lower conditions of temperature.

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SOME MINERAL ASSOCIATIONS

Sulphides are associated with quartz veins rather than calcite, while manganese generally is associated with the calcite veins. Gold is found in both types of veins.

As is generally true, some silver is alloyed with the gold. Bullion analyses show the preponderance by weight of gold over silver, thus bringing the veins into the gold-silver class very widely developed in the western United States. The bullion shows variations in fineness; that from Paracale, for instance, contains about 85.39 per cent gold with 13.36 per cent silver. Some copper and other metals are present. The occurrence of the gold has been mentioned under "the quartz phase." In addition, it is to be noted that gold rarely is associated with sphalerite. The gold has been precipitated almost from first to last during the period of vein filling. The auriferous pyrite frequently is one of the early minerals to form, while some of the richest free gold specimens show the gold to have been nearly the last mineral to form (Plate VII).

Silver is associated particularly with galena. Some galena ore has shown assays up to 1,500 grams silver and 30 grams gold per metric ton. However, the galena in many veins contains little silver. Bonanzas, secondary silver ores, are conspicuously rare or absent in the Philippines. The primary ores are low in silver content, and the tropical conditions of excessive rainfall and rapid erosion are unfavorable to the secondary enrichment of silver. The association of secondary silver deposits with desert regions is well known.

Tests on 300 samples of typical Philippine ores show tellurides to be either absent or very rare. Deposits of the Cripple Creek type are unknown. Likewise, fluorites and bismuth ore which frequently accompany telluride ores are unknown. Phonolite rocks are unknown.

Arsenic and antimony ores are rare except in the enargite (luzonite) veins of Mancayan-Suyoc.

Mercury has been found as would be expected from its occurrence elsewhere in the ore belt encircling the Pacific Ocean. Likewise, some platinum has been found in some of the alluvials. Chromite has been identified recently.

Tin is unknown, and granite—with which tin very frequently is associated—is of secondary importance. Pegmatite dikes may be said to be unknown, although veins approaching pegmatite in appearance have been seen. The group of minerals associated with tin, such as the flourine minerals, have not yet been identified.

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PLATE VII. FREE GOLD FROM TUMBAGA, AMBOS CAMARINES.

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THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1912

ISSUED BY THE DIVISION OF MINES
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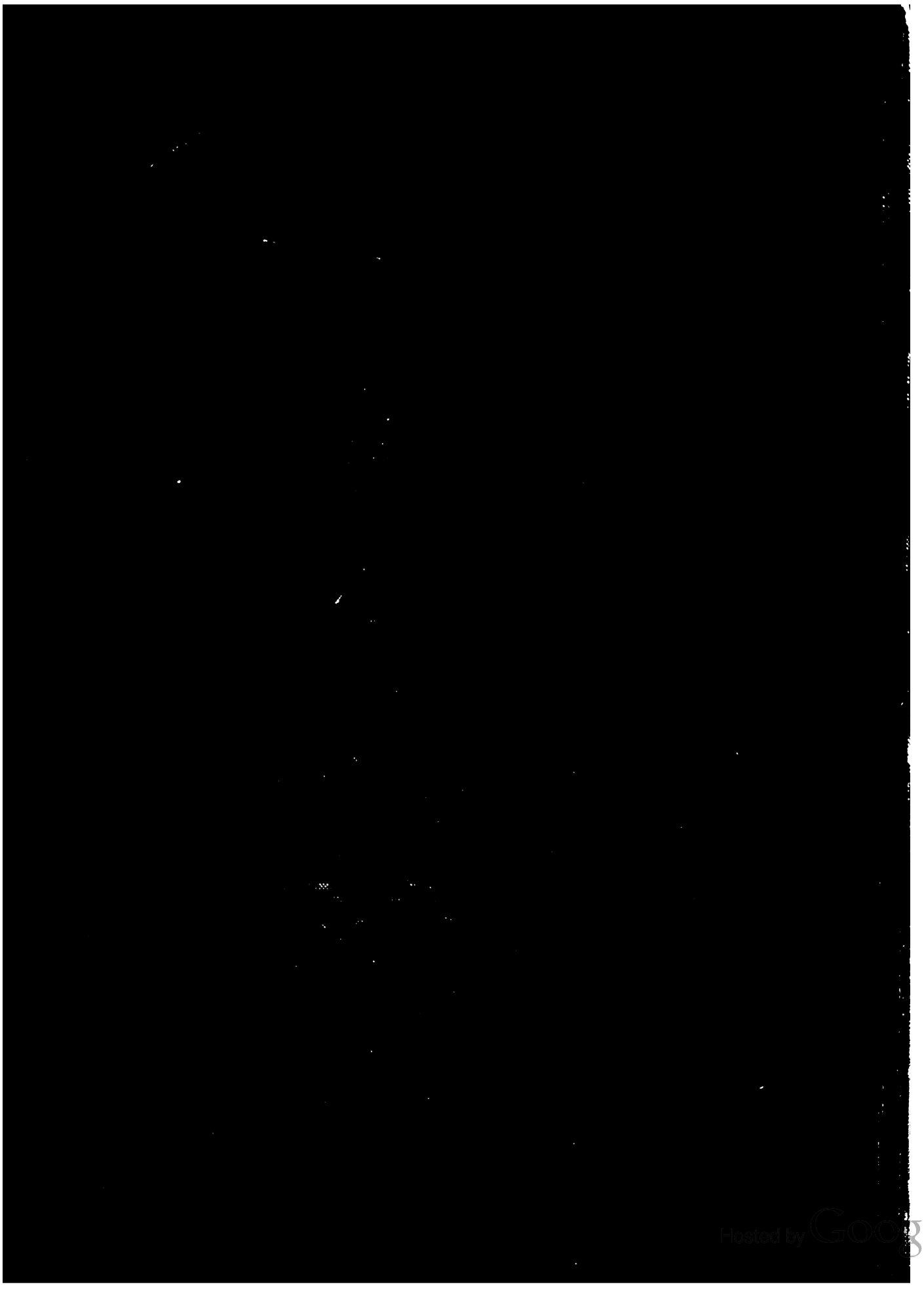
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